DRAFT FOR PUBLIC COMMENT

Dissolved Oxygen and Ammonia TMDL Development for Kokomo Creek, Indiana

Submitted by
The Indiana Department of Environmental Management
Office of Water Management
Assessment Branch
Environmental Toxicology and Chemistry Section
TMDL Program

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EXECUTIVE SUMMARY

Kokomo Creek is located in the Wildcat Creek watershed in north-central Indiana (see Figure 1). Kokomo Creek is approximately 16 miles long and its watershed drains 36 square miles. The stream was listed on Indiana's 1996 and 1998 section 303(d) lists due to impairments associated with low dissolved oxygen concentrations, high total ammonia concentrations, and a fish consumption advisory caused by polychlorinated biphenyl (PCB) contamination. As required by section 303(d) of the Clean Water Act, two Total Maximum Daily Loads (TMDLs) have been developed to address the dissolved oxygen and total ammonia listings for Kokomo Creek. The PCB impairment will be addressed at a later date.

Available water quality data and information on potential pollutant sources in the watershed were reviewed to develop the TMDLs. The low dissolved oxygen and high total ammonia nitrogen (NH3-N) concentrations at the downstream sampling sites were determined to be caused by wastewater treatment plant effluent and discharge from illicit septic system drainage tiles. The low dissolved oxygen concentrations at the upstream sites were determined to be due to the presence of nuisance attached algal growth associated with increased nutrient concentrations.

Instream numeric endpoints for the Kokomo Creek TMDLs were derived directly from Indiana's water quality criteria for dissolved oxygen and total ammonia nitrogen. In addition, a total phosphorus endpoint of 0.10 mg/L was identified based on an evaluation of the sampling data at "reference sites" in the watershed that had no apparent algae problem.

The magnitude of the point sources in the Kokomo Creek watershed were evaluated using a combination of instream sampling and discharge monitoring report (DMR) data. Effluent characteristics for the illicit and failing septic systems were estimated using literature values since no sampling data were available. To estimate the nutrient loads from the nonpoint sources in the watershed, the Generalized Watershed Loading Function (GWLF) model was used. The GWLF model is based on simple runoff, sediment, and groundwater relationships combined with empirical chemical parameters (Haith et al., 1992).

Because there are two inter-related problems affecting Kokomo Creek – the discharge from the point sources and the illicit septic systems and the extreme dissolved oxygen swings caused by the algal growths – a two-tiered approach was used for TMDL development. The QUAL2E model was used to assess the impact of the treatment plants and septic effluent during low-flow conditions, and the GWLF model was used to identify load reductions necessary to attain the total phosphorus endpoint. A margin of safety was incorporated into the analysis through the use of conservative analytical assumptions.

The results of the analysis indicated that the following load reductions will need to occur:

- The illicit septic system discharges must be eliminated.
- Loading from the point sources in the watershed must be reduced..
- Total phosphorus loadings from row crop agriculture will need to be reduced (by approximately 33%).

The elimination of the septic outfalls will be addressed by the formation of a Regional Sewer District (RSD) that will include the communities of Center, Oakford, and Hemlock. The wastes from these communities will be routed to a new plant that will replace the existing Taylor High School facility. The Kokomo Regency Mobile Home Park will be immediately connected to the new sewer system and the Timbernest Apartments will eventually be connected. Permit limits for the new facility will be implemented via the National Pollutant Discharge Elimination System (NPDES) program. An Indiana Department of Natural Resources Lake and River Enhancement has been proposed that would address the total phosphorus reductions from row crops. This project would include the installation of filter strips and other conservation measures to reduce nutrient loadings. A separate Sampling and Analysis Work Plan describes in detail the follow-up monitoring that will occur to ensure that the load reductions and instream water quality goals are met.

1.0 INTRODUCTION

1.1 Background

Section 303(d) of the Clean Water Act requires States, Territories, and authorized Tribes to identify waters for which technology-based effluent limitations are not stringent enough to achieve applicable water quality standards. Lists of these waters (the section 303(d) lists) are made available to the public and submitted to the U.S. Environmental Protection Agency (USEPA) in April of every even-numbered year. As part of the 1996 and 1998 303(d) listing processes, the Indiana Department of Environmental Management (IDEM) identified Kokomo Creek as an impaired stream. The parameters of concern for Kokomo Creek were ammonia, dissolved oxygen, and Polychlorinated Biphenyls (PCBs) (due to a fish consumption advisory).

The Clean Water Act and USEPA regulations require that Total Maximum Daily Loads (TMDLs) be developed for all waters on the section 303(d) lists. The requirements of a TMDL are described in 40 Code of Federal Regulations (CFR) 130.2 and 130.7 and section 303(d) of the Clean Water Act, as well as in various guidance documents (e.g., USEPA, 1991; USEPA, 1997a). A TMDL is defined as "the sum of the individual wasteload allocations for point sources and load allocations for nonpoint sources and natural background" such that the capacity of the waterbody to assimilate pollutant loadings is not exceeded. A TMDL is also required to be developed with seasonal variations and must include a margin of safety that addresses the uncertainty in the analysis. A TMDL is often expressed using the following equation:

$$\text{TMDL} = \sum \text{WLA} + \sum \text{LA} + (\text{MOS})$$

where WLA = wasteload allocation, LA = load allocation, and MOS = margin of safety. The MOS is in parenthesis because it can be incorporated into the TMDL either explicitly or implicilty. Pursuant to the regulations at 40 CFR 130.6, States are to develop water quality management plans to implement water quality control measures such as TMDLs.

TMDLs for phosphorus, CBOD5, and NH3-N for Kokomo Creek have been developed that address the impairments caused by low dissolved oxygen and high total ammonia concentrations. (It is expected that a future TMDL will be developed to address the PCB impairment.) All available water quality data have been reviewed and the potential sources of oxygen-depleting pollutants and total ammonia have been estimated. The necessary loading reductions have also been calculated.

1.2 Problem Statement

Kokomo Creek is located in the Wildcat Creek watershed (U.S. Geological Survey (USGS) Cataloging Unit 05120107) in north-central Indiana (see Figure 1). Kokomo Creek is approximately 16 miles long and its watershed drains 36 square miles. The confluence of Kokomo Creek and Wildcat Creek is located in the industrial city of Kokomo. Most of the creek

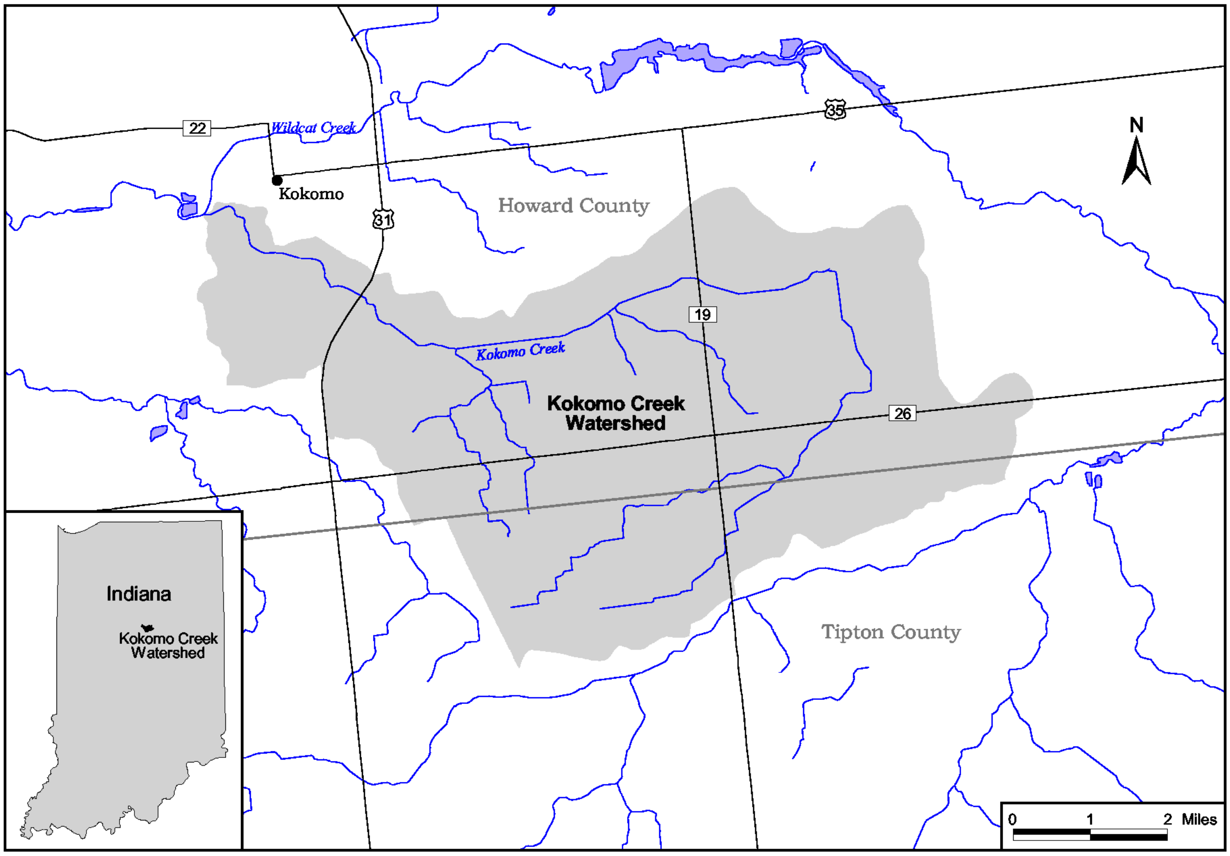

Figure 1. Location of Kokomo Creek watershed.

is located in Howard County, which has experienced a very slight (less than 1%/year) increase in population from 1990 to 1998 (80,827 persons to 83,452 persons (Bureau of the Census, 1999)).

The upper portion of the watershed is predominantly agricultural with few residences located along the creek. The stream has been channelized in several places. A 1994 study of the creek indicated that "the riparian zone had various amounts of vegetative growth but most of the stream was exposed to sunlight. The water appeared muddy and turbid with moderate algae growth" (IDEM, 1996).

The lower portion of Kokomo Creek is more shaded and flow is typically characterized as pool-riffle-pool. The creek travels a meandering course through residential, commercial, and industrial areas. The 1994 study indicated that the "riparian zone varies from weeds, shrubs, and trees along the majority of this reach to open mowed grassy areas in Highland Park. The water varied from clear in riffle areas to turbid and greenish-brown in a small lake area created by a spillway in the city park" (IDEM, 1996).

Kokomo Creek is classified as a county regulated drain and, especially upstream, is periodically maintained for flood control purposes. Trees and other vegetation are removed when they threaten agricultural drainage tiles or might causes instream debris dams. This alteration of the natural channel precludes Kokomo Creek from providing certain levels of habitat structure.

Kokomo Creek was first placed on the 1996 section 303(d) list of impaired waters because of monitoring that was performed by IDEM in 1994 (see section 2.2.1). The results of this monitoring indicated that there were violations of the minimum dissolved oxygen criterion at three separate sampling sites. The results of the monitoring also indicated that one of the treatment plants in the watershed was discharging total NH3-N at an elevated concentration (6.9 mg/L).

Further investigations of these problems indicated that there were several interrelated causes of the dissolved oxygen impairment. The dissolved oxygen violation at the downstream sampling site was determined to be a result of organic enrichment caused by both wastewater treatment plant discharge and illicit septic system effluent. The septic system effluent results from the fact that several communities in the watershed have illegally connected their septic systems to a series of tiles which drain into Kokomo Creek. The dissolved oxygen concentrations at the upstream sites were determined to be due to the presence of nuisance attached algal growth, which in turn was thought to be a result of increased nutrient concentrations. The algal growth is also exacerbated by the altered morphology of the stream channel and reduced riparian shading. The primary source of the nutrients was believed to be runoff from the row crop agriculture in the watershed. The remaining sections of this document will explain how these problems were quantified and will discuss what can be done to address them.

1.3 Applicable Water Quality Standards

States are responsible for setting water quality standards to protect the physical, biological, and chemical integrity of their waters. The three components of water quality standards include:

- Designated uses (such as drinking water supply, aquatic life protection, recreation, etc).
- Narrative and numeric criteria designed to protect these uses.
- An antidegradation policy that provides a method of assessing activities that might affect the integrity of waterbodies.

Kokomo Creek is designated for whole body contact recreation and maintenance of a warm water fish community. Indiana's water quality standards (Regulation 327 Indiana Administrative Code 2-1) establish the criteria that apply to these designated uses. The dissolved oxygen criteria for the creek are 4.0 mg/L minimum and 5.0 mg/L daily average. The total ammonia criterion for protection of warm water fish is narrative and reads as follows:

"(5) The following criteria will be used to regulate ammonia:

> (A) Except for waters covered in clause (B), at all times, all waters outside of mixing zones shall be free of substances in concentrations which, on the basis of available scientific data, are believed to be sufficient to injure, be chronically toxic to, or be carcinogenic, mutagenic, or teratogenic to humans, animals, aquatic life, or plants."

Indiana has quantified this narrative criterion using EPA's 1992 guidance. Based on this guidance, the chronic criteria for total NH3-N, which vary by instream pH and temperature, are shown in Table 1.

Table 1. Criterion continuous concentrations for total NH3-N.

pH	Temperature (˚C)							
	0	**5**	**10**	**10**	**15**	**20**	**25**	**30**
6.5	2.504	2.339	2.217	2.217	2.131	2.076	1.450	1.025
7.0	2.505	2.341	2.220	2.220	2.135	2.081	1.455	1.030
7.2	2.506	2.342	2.222	2.222	2.138	2.086	1.460	1.035
7.4	2.508	2.345	2.226	2.226	2.144	2.094	1.468	1.043
7.6	2.511	2.349	2.232	2.232	2.152	2.106	1.480	1.055
7.8	2.118	1.983	1.887	1.887	1.823	1.789	1.261	0.904
8.0	1.499	1.406	1.341	1.341	1.299	1.280	0.908	0.656
8.2	0.950	0.894	0.855	0.855	0.833	0.826	0.591	0.432
8.4	0.604	0.570	0.548	0.548	0.538	0.539	0.391	0.290
8.6	0.386	0.366	0.355	0.355	0.352	0.358	0.265	0.201
8.8	0.248	0.237	0.233	0.233	0.235	0.244	0.185	0.145
9.0	0.161	0.156	0.156	0.156	0.161	0.172	0.135	0.109

2.0 TMDL ENDPOINT AND WATER QUALITY ASSESSMENT

2.1 Selection of a TMDL Endpoint

The establishment of instream numeric endpoints[1] is a significant component of the TMDL process. The numeric endpoints serve as a measure of comparison between observed instream conditions and conditions that are expected to restore the designated uses of the waterbody. The TMDL identifies the load reductions that are necessary to meet the endpoint, thus resulting in the attainment of applicable water quality standards.

Numeric endpoints are derived directly or indirectly from state narrative or numeric water quality standards. The applicable dissolved oxygen and total NH3-N endpoints and target values for the Kokomo Creek TMDL are available directly from the Indiana state water quality regulations (see section 1.2). That is, dissolved oxygen concentrations must stay above 4.0 mg/L and must average at least 5.0 mg/L per day. Total ammonia nitrogen concentrations cannot exceed the limits identified in Table 1.

In addition to the total NH3-N and dissolved oxygen endpoints, a supplementary total phosphorus endpoint has been selected for the Kokomo Creek TMDL. As discussed previously, the upstream portion of Kokomo Creek is impaired due to the nuisance growths of attached algae. It is believed that one of the reasons these algae have reached nuisance levels is nutrient (and specifically phosphorus) enrichment.

Many natural factors combine to determine rates of plant growth in a waterbody. First of these is whether sufficient phosphorus and nitrogen exist to support plant growth. The absence of one of these nutrients generally will restrict plant growth. A total phosphorus (TP) endpoint of 0.10 mg/L was selected as a target for the upstream portion of Kokomo Creek. This target was selected based on an evaluation of the sampling data showing that "reference sites" with no apparent algae problem had an average TP concentration of approximately 0.10 mg/L. Reference sites were those sites within the Wildcat Creek watershed (the larger watershed of which Kokomo Creek is a part) that had an average dissolved oxygen concentration of at least 7.0 mg/L and which had dissolved oxygen swings of less than 2.0 mg/L per day. A TP target of 0.10 mg/L has also been proposed by the Ohio Environmental Protection Agency for protection of warmwater habitat in 20 mi^2 to 200 mi^2 watersheds in the Eastern Corn Belt Plains ecoregion (the same ecoregion in which Kokomo Creek is located (OEPA, 1999)). USEPA (1986) has also proposed a TP target of 0.10 mg/L.

Phosphorus was selected as the TMDL endpoint rather than total nitrogen (TN) because the TN:TP ratio (based on the available sampling data) is 25:1; TN:TP ratios greater than 7.2

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[1]A TMDL endpoint is a target value for a water quality parameter, such as phosphorus, that is expected to result in the attainment of water quality standards. In some cases the TMDL endpoint is already specified by the numeric criterion that applies to the waterbody (e.g., a minimum dissolved oxygen concentration of 5.0 mg/L). In other cases site-specific TMDL endpoints are required.

typically imply that phosphorus is the limiting nutrient (Chapra, 1997). Although it would be preferable to select a dissolved phosphorus endpoint (because algae in streams are believed to respond more to readily bioavailable dissolved phosphorus) no dissolved phosphorus data for the watershed are available.

2.2 Discussion of Available Data Sources

2.2.1 Inventory and Analysis of Water Quality Monitoring Data

There are no long-term, fixed monitoring stations located on Kokomo Creek. However, IDEM conducted ambient stream monitoring of the creek on 6/17/94, 7/31/98, and 9/3/98. As part of the IDEM monitoring activities, stream samples were collected at 11 sites along Kokomo Creek (see Figure 2). The samples were collected as three-part composites to account for diurnal fluctuations and changes in stream chemistry that occur during a 24-hour sampling period. The stream samples were collected from the centroid of flow, just below the surface of the water. The samples were collected at mid-morning, late afternoon, and before dawn the following morning. The effluent from the five NPDES facilities that discharge to the creek were also sampled. Mile point locations of the sampling sites are given in Table 2.

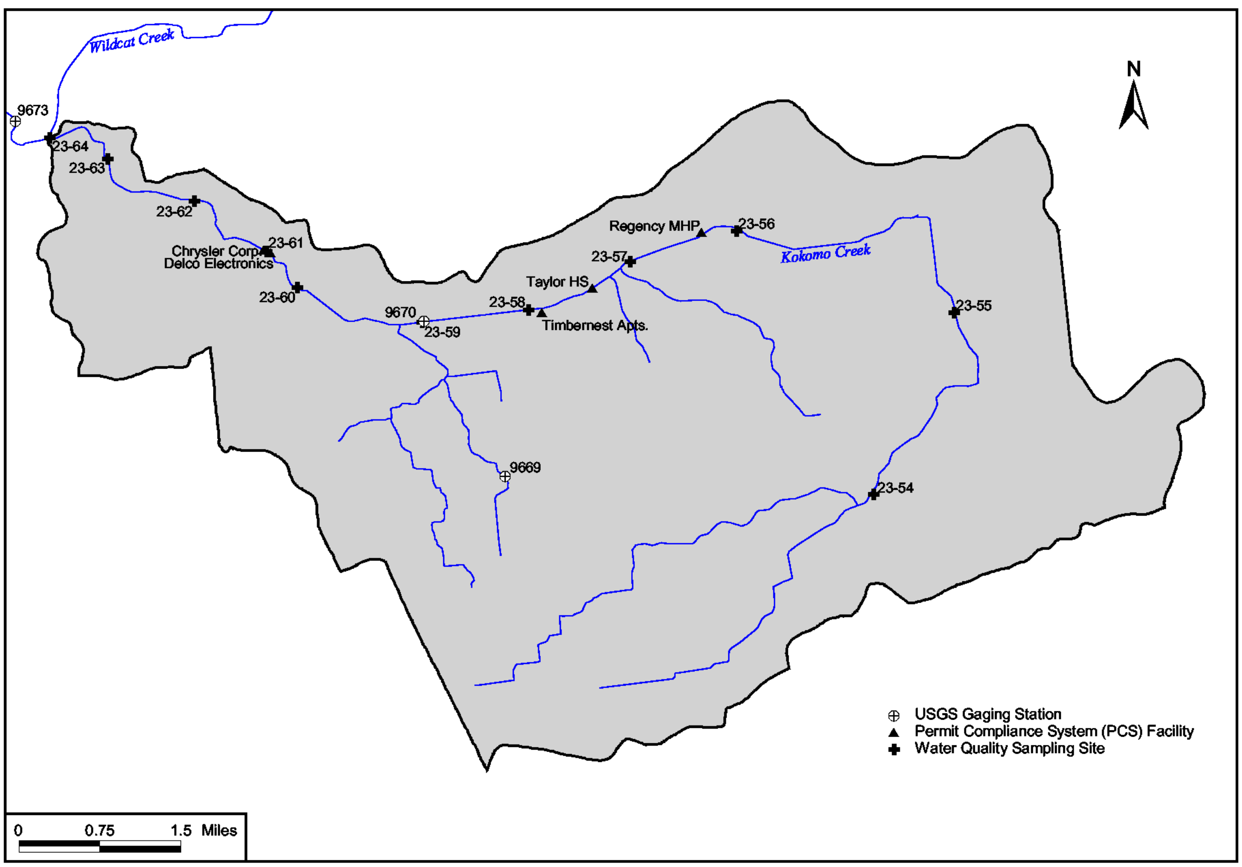

Figure 2. Location of IDEM sampling sites, point source dischargers, and USGS gaging station.

Table 2. Locations of Kokomo Creek sampling sites.

Sampling Site	Mile Point
23-64	0.09
23-63	0.81
23-62	1.65
Delco Electronics (NPDES facility)	2.78
Chrysler Corp. (NPDES facility)	2.78
23-61	2.78
23-60	3.25
23-59	4.53
Timbernest Apartments. (NPDES facility)	5.64
23-58	5.64
Taylor High School (NPDES facility)	6.08
23-57	6.52
Regency Mobile Home Park (NPDES facility)	7.24
23-56	7.67
23-55	10.51
23-54	12.75

The parameters measured during the stream surveys included: total ammonia nitrogen, nitrate-nitrite nitrogen, organic nitrogen, total Kjeldahl nitrogen, total phosphorus, 5-day carbonaceous biochemical oxygen demand (CBOD5), chemical oxygen demand, dissolved oxygen, pH, temperature, turbidity, and conductivity. Appendix A contains the results of the sampling for all parameters for each sampling date.

Table 3 displays the dissolved oxygen measurements for the sampling. During the 6/17/94 survey three instream violations of the minimum dissolved oxygen criteria were observed. The flow at the USGS gage on Kokomo Creek was 4.3 cfs during the sampling. This is a relatively low flow condition since the average long-term flow at the gage is 23 cfs (see section 2.2.2 below). Sampling sites 23-54, 23-56, and 23-59 each had a dissolved oxygen measurement below the minimum of 4.0 mg/L. The measurements at two of these three sites (23-54 and 23-56) also displayed significant diurnal swings (i.e., fluctuations between the minimum and maximum measurements), indicating the presence of algal populations. Instream plant communities can cause diurnal fluctuations because photosynthesis contributes dissolved oxygen to the stream during the day but respiration depletes dissolved oxygen at night. No sites on Kokomo Creek violated the 5.0 mg/L average dissolved oxygen criterion during the 6/17/94 survey and the average dissolved oxygen concentrations for all of the sampling sites was 6.3 mg/L.

There were no observed instream total NH3-N violations during the 6/17/94 sampling. However, the Kokomo Regency mobile home park discharge effluent was 6.9 mg/L total NH3-N. Site 23-57, the site immediately downstream (0.6 miles) of the Kokomo Regency facility, was observed to have an instream total NH3-N concentration of 0.3 mg/L. The applicable criterion for the observed temperature (26°C) and pH (7.8) at that site is a total NH3N concentration equal to or less than 1.178 mg/L.

Table 3. Kokomo Creek dissolved oxygen concentrations for three sampling dates.

Sampling Site	**Sampling Date**									
	6/17/94			**7/31/98**			**9/03/98**			
	Max DO (mg/L)	Mean DO (mg/L)	Min DO (mg/L)	Max DO (mg/L)	Mean DO (mg/L)	Min DO (mg/L)	Max DO (mg/L)	Mean DO (mg/L)	Min DO (mg/L)	Violations
Timbernest Apts	N/A	4.8	N/A	N/A	N/A	N/A	3	3.0	2.9	
Taylor High School	N/A	N/A	N/A	N/A	N/A	N/A	7.9	7.9	7.8	
Regency MHP	N/A	4.9	N/A	7.3	5.3	3.9	2.3	2.1	1.9	
Delco Electronics	N/A	8.6	N/A	N/A	N/A	N/A	8.0	8.0	8.0	
Chrysler Corp	N/A	7.1	N/A	N/A	6.0	N/A	6.1	6.1	6.1	
23-64	7.5	6.5	5.0	8.3	8.0	7.7	8.8	8.0	7.0	
23-63	8.5	7.3	5.0	8.4	8.3	8.2	8.5	8.4	8.2	
23-62	7.9	6.6	4.5	8.6	8.2	7.8	10.2	8.6	6.9	
23-61	7.8	6.7	4.7	8.1	7.8	7.6	9.5	8.1	6.8	
23-60	7.3	6.8	6.2	8.0	7.7	7.5	9.0	8.1	7.2	
23-59	6.3	5.0	3.4	7.4	7.2	7.0	6.7	6.1	6.0	√
23-58	6.5	5.9	5.4	7.6	7.3	7.0	6.1	5.9	5.6	
23-57	6.6	5.8	5.1	8.0	7.3	6.7	6.1	5.3	4.4	
23-56	7.9	5.6	3.6	10.4	8.4	7.0	13.5	8.0	3.8	√√
23-55	11.6	6.8	4.3	8.3	7.1	6.5	11.3	8.4	6.6	
23-54	9.4	5.9	3.7	8.1	7.5	7.1	7.4	7.1	6.8	√

There were no observed instream dissolved oxygen or total NH3-N violations observed during the 7/31/98 sampling. The flow for this sampling event was 16 cfs (also below average but above the flow measured in 1994). The lowest observed instream dissolved oxygen concentration was 6.5 mg/L at site 23-55. The average instream dissolved oxygen measurements for all of the sampling sites was 7.7 mg/L.

The flow for the 9/3/98 sampling event was 2.9 cfs, the lowest of the three sampling dates. There was one violation of the instream minimum dissolved oxygen criterion (3.8 mg/L at site 23-56). The dissolved oxygen concentrations at this site fluctuated from a minimum of 3.8 mg/L to 13.5 mg/L, a strong indication of the presence of algae. The average dissolved oxygen concentration for all of the instream sampling sites during the 9/3/98 sampling was 7.5 mg/L. There were no violations of the total NH3-N criterion during the 9/3/98 sampling. The Kokomo Regency discharge was 10 mg/L total NH3-N and the observed concentration at site 23-57 was 0.34 mg/L (criterion is equal to or less than 2.08 mg/L at observed pH of 7.7 and 20°C).

2.2.2 Streamflow Data

There is one active gaging station on Kokomo Creek. Gage 03333600 is located at mile point 4.2 (see Figure 2) and drains approximately 24.7 mi^2 (68% of the watershed). Flow data from the station are available from 1959 to current. The average discharge, low-flow discharge, and flow conditions at the time of the IDEM sampling are shown in Table 4. Data from this gage show that flows are typically greatest in February, March, and April and lowest in August, September, and October.

Table 4. Kokomo Creek USGS Gage: Historic flow conditions and conditions at time of IDEM sampling.

Date	Flow at USGS Gage 03333600 (cfs)
6/17/94	4.3
7/31/98	16.0
9/03/98	2.9
Average long-term discharge	23.0
7Q10	0.3

Source: USGS, 1999; USGS, 1996

2.2.3 Selection of a Critical Condition

TMDL development must define the environmental conditions that will be used when defining allowable loads. Many TMDLs are designed around the concept of a "critical condition." The critical condition is defined as the set of environmental conditions that, if controls are designed to protect, will ensure attainment of objectives for all other conditions. For example, the critical condition for control of a continuous point source discharge is the drought stream flow. Point source pollution controls designed to meet water quality standards for drought flow conditions will ensure compliance with standards for all other conditions. The critical condition for a wet weather-driven source may be a particular rainfall event, coupled with the stream flow associated with that event.

There are two types of problems in Kokomo Creek: (1) the discharge of total ammonia and oxygen-depleting substances from the point sources and septic outfalls and (2) high nutrient loading to the upstream portion of the watershed from agricultural sources. As mentioned above, the critical conditions for point source dominated systems occur during summer periods of low flow and low dilution of effluent outputs. The 7Q10 flow value is typically chosen as the critical condition for this situation. The 7Q10 flow value represents the 7-day low flow period that occurs on average every 10 years in a stream system. Critical conditions for instream temperature and pH were based on current IDEM guidelines (i.e., default temperatures of 24 degrees Celsius and pH values of 7.8 standard units in the summer and 10 degrees Celsius/pH 7.8 in the winter).

Nutrient sources to the upstream portion of Kokomo Creek arise from a mixture of continuous and wet weather-driven sources. For example, loading from failing septic systems is assumed to be relatively constant over time whereas agricultural runoff will be greatest during wet weather (and presumably higher river flow) periods. For this reason, and because algal growth is expected to respond more to long-term nutrient concentrations rather than to acute concentrations, no single critical condition exists. The TMDL will therefore examine the combined impact of both continuous and wet-weather sources on long-term nutrient concentrations in the upstream portion of the watershed (defined as subwatersheds 5, 6 and 7 (see Figure 4 below)).

3.0 Source Assessment

The purpose of the source assessment is to demonstrate that all pollutant sources have been considered, and significant sources estimated, in order to help determine the degree of loading reductions needed to meet the TMDL endpoints and allocation of loading allowances among sources.

3.1 Assessment of Point Sources

There have historically been five NPDES facilities located in the watershed: one school, one apartment complex, two industrial facilities, and a mobile home park. The permit for the Chrysler Transmission Plant was voided 4/7/99 and the facility now has a general stormwater permit. The location of each facility is shown in Figure 2 and the mile points are shown in Table 2. The standard industrial code, average flows, and type of treatment of each facility are listed in Table 5 and Table 6 lists the applicable permit limits.

Table 5. Point sources located along Kokomo Creek.

Facility ID	Facility Name	Standard Industrial Code Description	Average Design Flow	Type of Treatment
IN0001422	Chrysler Transmission Plant	Wiring Harness Sets, Other than Ignition; Block Heaters	N/A	Individual permit was voided 4/7/99 and they now have a general stormwater permit.
IN0001830	Delco Electronics Corporation	Semiconductors and Related Devices	8.31 mgd (12.857 cfs)	Noncontact cooling water effluent.
IN0041131	Taylor Elementary and High School	Elementary and Secondary Schools	0.0284 mgd (0.044 cfs)	Extended aeration with effluent chlorination (chlorination to eventually be replacted with ultraviolet light disinfection).
IN0041912	Timbernest Apartments	Operators of Apartment Buildings	0.015 mgd (0.023 cfs)	Extended aeration with effluent chlorination followed by a 2-day terminal lagoon.
IN0031844	Kokomo Regency Mobile Home Park	Operators of Residential Mobile Home Sites	0.0914 mgd (0.141 cfs)	Extended aeration with secondary clarifier, effluent chlorination, and a two-cell terminal lagoon.

A review of the discharge monitoring reports (DMRs) for these facilities from 1993 to 1998 indicates that several of the facilities have been in violation of their permits for various parameters. For example, the Kokomo Regency Mobile Home Park and Timbernest Apartments have each recorded violations of their permit limits.

Table 6. Permit limits for Kokomo Creek NPDES facilities.

Facility Name	Total NH3-N	CBOD5	Dissolved Oxygen
Delco Electronics Corporation	None	None	None
Taylor Elementary and High School	None	Summer: Monthly Avg 15 mg/L Maximum Weekly Avg 23 mg/L Winter: Monthly Avg 25 mg/L Maximum Weekly Avg 40 mg/L	Summer: Daily Minimum: 6 mg/l Winter: Daily Minimum: 5 mg/l
Timbernest Apartments	Summer: Monthly Avg: 3.9 mg/L Maximum Weekly Avg: 5.8 mg/L Winter: Monthly Avg: 6.0 mg/L Maximum Weekly Avg: 9.0 mg/L	Monthly Avg: 25 mg/L Maximum Weekly Avg: 40 mg/L	None

3.2 Assessment of Nonpoint Sources

The land uses in the Kokomo Creek watershed are listed in Table 7 and are shown in Figure 3. Land uses consist predominantly of row crops and pasture/hay land, although the lower portion of the watershed includes a significant percentage of residential and built-up land. The primary crops in the watershed are corn and soybeans.

Table 7. Land uses in the Kokomo Creek watershed.

Land Use	**Acres**	%
Row Crops	17,508.7	74.82
Pasture/Hay	1,937.9	8.28
Low Intensity Residential	1,761.5	7.53
Urban/Recreational Grasses	682.6	2.92
Deciduous Forest	506.5	2.16
Commercial/Industrial/Transportation	491.9	2.10
Woody Wetlands	401.4	1.72
High Intensity Residential	81.5	0.35
Open Water	19.6	0.08
Emergent Herbaceous Wetlands	9.2	0.04
Evergreen Forest	0.7	0.00
Mixed Forest	0.1	0.00
Total	**23,401.6**	**100.00%**

Source: Multi-resolution Land Characteristics land use data (MRLC, 1992).

Potential nonpoint sources of nutrients and oxygen-depleting substances from these land uses include crop production, fertilizer application, failing septic systems, urban runoff from residential areas, and animal feedlots. Further investigation also indicated that the sewage from several of the small communities (Oakford, Center, and Hemlock) in the watershed was being discharged to the creek untreated via a series of drainage tiles (Paulus, 1999; Howard County Health Department, 1995; 1996; 1998).

To estimate the nutrient loading from these sources the Generalized Watershed Loading Function (GWLF) model was used. The GWLF model is based on simple runoff, sediment, and groundwater relationships combined with empirical chemical parameters (Haith et al., 1992). It evaluates streamflow, nutrients, soil erosion, and sediment yield values from complex watersheds. Runoff is calculated by means of the Natural Resources Conservation Service (NRCS) curve number equation. The Universal Soil Loss Equation (USLE) is applied to simulate erosion. Urban nutrient loads are computed by exponential accumulation and wash-off functions and groundwater nutrient loads to the stream are determined as a function of the background nutrient concentration in groundwater, the watershed area, and the groundwater discharge to the stream.

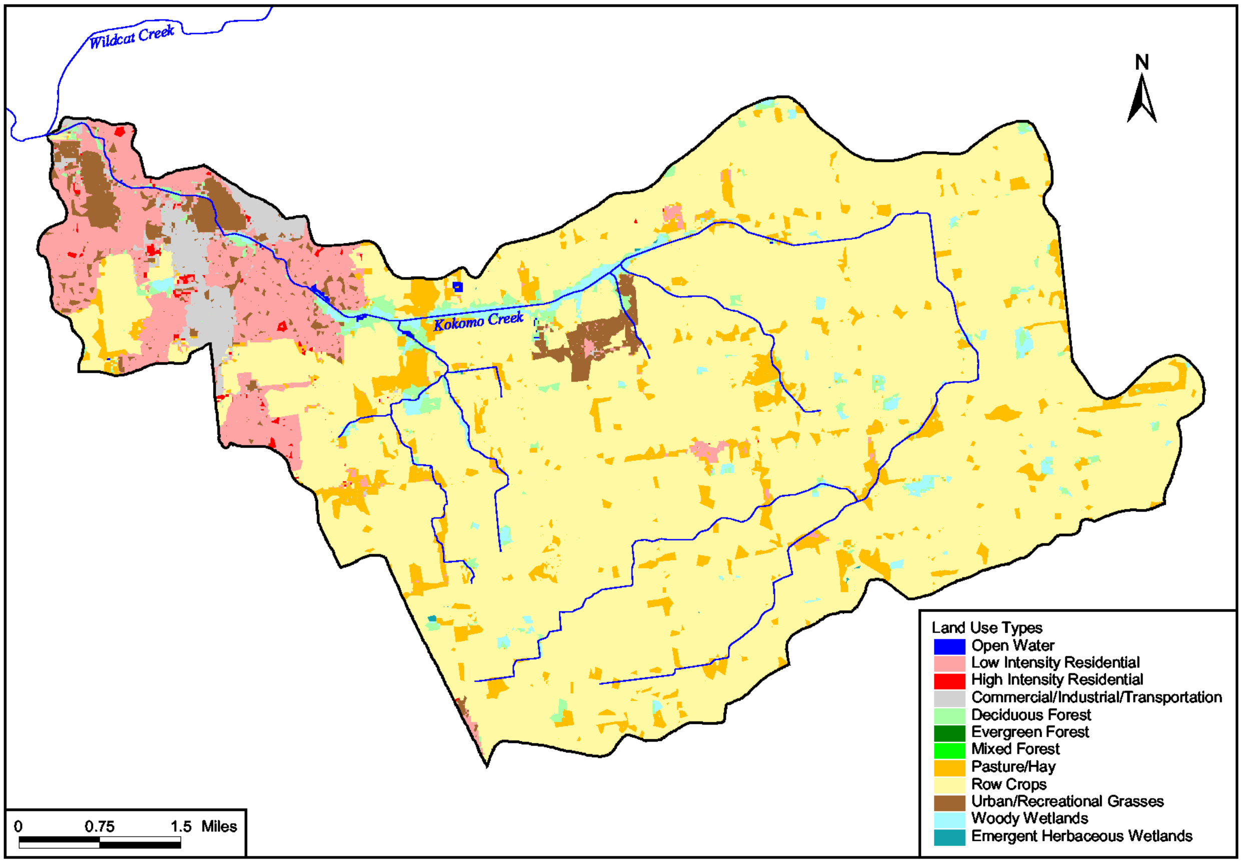

Figure 3. Kokomo Creek land uses.

To use the GWLF model the Kokomo Creek watershed was first delineated into seven subwatersheds (see Figure 4). The nutrient loading estimates focused on subwatersheds 5, 6, and 7 since this is the portion of the watershed where the increased nutrient loads are believed to have lead to increased algal populations and subsequent dissolved oxygen problems. Land use and soil characteristics data for these subwatersheds were input to the GWLF model. Daily precipitation and temperature data for the station at the Kokomo Post Office were obtained from the Midwestern Climate Center in Champaign, Illinois (MCC, 1999).

Nutrient transport characteristics and other information required to run the model were obtained from site-specific information where available and literature values otherwise. For example, the timing of fertilizer application was obtained from the Indiana Agricultural Statistics Fertilizer Usage Table (OARP, 1999) and the percentage of acres farmed using conservation tillage (approximately 20%) was obtained from the Howard County Soil and Water Conservation District (Howard County Soil and Water Conservation District, 1996). Soil and groundwater nitrogen and phosphorus concentrations were obtained from literature values available in the GWLF User's Manual (Haith et al., 1992). All of the model input values are available in Appendix B.

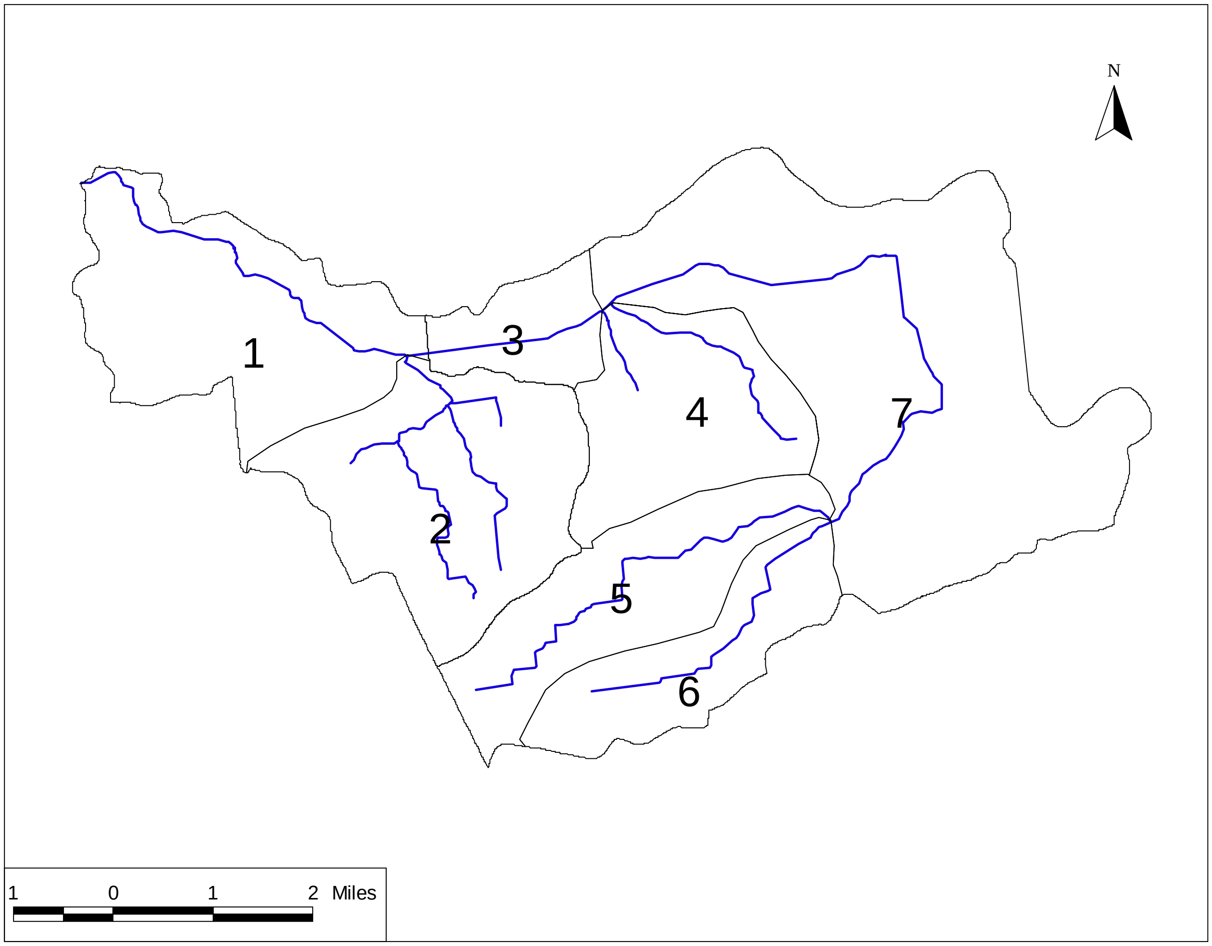

Figure 4. Kokomo Creek subwatersheds.

The model's streamflow parameters (seepage coefficient and evapotranspiration parameters) were modified within the acceptable limits so that the simulated streamflow adequately matched the observed streamflow for the time period 1994 to 1999. The model was then run to estimate annual nitrogen and phosphorus loadings. The results are shown in Table 8 and agree favorably with a separate estimate of total annual loadings made using the observed sampling and flow data.

It is apparent from Table 8 that the largest source of nutrient loading is from non-conservation tillage row crop agriculture. Conservation tillage row crop agriculture, and groundwater are the other significant sources of nitrogen and phosphorus in the upstream portion of the watershed.

Table 8. Estimated annual nutrient loadings for subwatersheds 5, 6, and 7 within Kokomo Creek.

Source	Area (ac)	Dis. N (t)	Tot. N (t)	Dis. P (t)	Tot. P (t)
Row Crop	8,871	21.42	29.45	3.23	6.83
Row Crop (with conservation tillage)	2,217	4.26	4.76	0.65	0.87
Groundwater	--	30.07	30.07	0.86	0.86
Point Source	--	1.86	1.86	0.24	0.24
Pasture/Hay	963	0.51	0.53	0.04	0.05
Wetlands	175	0.02	0.02	0.02	0.02
Low Intensity Residential	50	0.00	0.01	0.00	0.00
High Intensity Residential	2	0.00	0.00	0.00	0.00
Commercial/Urban	1	0.00	0.00	0.00	0.00
Deciduous Forest	141	0.01	0.01	0.00	0.00
Urban Grass	9	0.00	0.00	0.00	0.00
Total	12,429	58.15	66.71	5.04	8.87

(t) = metric tons (1,000 kg)

4.0 MODELING PROCEDURE: LINKING THE SOURCES TO THE ENDPOINT

Modeling procedures are used to create a direct predictive relationship between external loadings and the resulting water quality condition. Once the model is developed, load allocations and wasteload allocations can be selected to define the conditions under which predicted water quality will meet water quality standards. Available modeling techniques include empirical relationships, analytical equations, and numerical (computer) models of a wide range of complexity.

As discussed previously there are two inter-related problems affecting Kokomo Creek – the discharge from the point sources and the straight pipe septic systems and the extreme dissolved oxygen swings caused by the algal growths. A two-tiered approach was selected to address these two problems. The QUAL2E model was used to assess the impact of the treatment plants and septic systems during low-flow conditions, and a long-term total phosphorus concentration target was identified for the upstream portion of the watershed where algae have been a problem. These two approaches are discussed separately in this section.

4.1 QUAL2E Modeling

The EPA-supported QUAL2E model was chosen for simulating point source and straight pipe septic loadings in the Kokomo Creek watershed. QUAL2E is a one-dimensional model that can simultaneously simulate hydrodynamics and the transport and transformation of water quality variables. The model is applicable to dendritic stream systems, such as Kokomo Creek, that are well mixed. It allows for the inclusion of multiple waste discharges and withdrawals and is perhaps the most widely used computer model for simulating stream water quality (Chapra, 1997). It is capable of simulating up to 15 water-quality constituents (Table 9).

Table 9. Constituents Simulated by QUAL2E Model

Dissolved Oxygen Biochemical oxygen demand Temperature Algae as chlorophyll-*a* Organic nitrogen as N	Ammonia as N Nitrite as N Nitrate as N Organic phosphorus as P Dissolved phosphorus as P	Coliform bacteria Arbitrary nonconservative constituent Conservative constituent #1 Conservative constituent #2 Conservative constituent #3

QUAL2E represents the stream as a system of reaches of variable length, each of which is subdivided into computational elements that have the same incremental length in all reaches. The basic equation used in the model is the one-dimensional advection-dispersion mass transport equation. QUAL2E can operate as either a steady-state or dynamic model. In steady-state mode, the model can be used to examine the effects of waste loads on instream water quality. When used in conjunction with a field sampling program, the steady-state mode can be used to determine the magnitude and characteristics of point and nonpoint source loadings. Dynamic modeling with QUAL2E allows the modeler to examine the diurnal effects of variability in meteorological data on in-stream water quality and to evaluate diurnal DO variations due to floating algal growth and respiration.

4.1.2 Model Configuration

The following data are necessary to configure and calibrate the QUAL2E water quality model:

- Delineation of the stream into reaches having similar hydraulic characteristics
- Stream geometry or flow-depth and flow-velocity relationships for the stream reaches
- Point source locations and discharge loading data
- Tributary locations and discharge loading data
- Background concentrations of nutrients and dissolved oxygen
- Climatological data (air temperature, solar radiation, wind speed, cloud cover)
- Kinetic constants and rate coefficients for chemical transformations
- Instream water quality and flow data.

The study area for the QUAL2E model of Kokomo Creek extends from the confluence of Kokomo Creek and Wildcat Creek (mile 0.0) to the headwaters (mile 16.0). The study area was divided into 17 reaches based on hydraulic conditions; that is, each reach had similar flow, depth, and velocity characteristics. The reaches were further subdivided into computational elements. Each computational element in the model had a fixed length of 0.171 miles. The entire system consisted of 171 computational elements. The model reaches and locations of the tributary and point source discharges are shown in Figure 5.

The IDEM sampling data were used as input to the QUAL2E model for the point source facilities. The straight pipe septic outfalls from the three communities in the watershed were also input to the model; the locations and magnitude of the outfall pipes were based on the information provided in several reports prepared by the Howard County Health Department (1995, 1996, and 1998). This information is summarized in Table 10.

Table 10. Location and magnitude of community septic system drain tiles.

Community	**Location of outfall**	**Magnitude**
Hemlock	"The elaborate network of drain tiles eventually connects to a main tile on the north side of State Road 26. This tile extends north... and eventually surfaces at the northeast corner of county road 300 south and 400 east. This drain tile then becomes Taylor Run Ditch and meanders through a subdivision known as Winding Brook. The ditch heads further northeast behind several homes along county road 400 east, eventually making its way to Kokomo Creek."	52 homes/ 54% illegal
Center	"The network of drain tiles eventually connects to a main tile on the north side of Center. This tile extends north approximately 2500 feet...eventually emptying into Kokomo Creek."	73 homes/ 25% illegal

Community	Location of outfall	Magnitude
Oakford	“The elaborate network of drain tiles eventually connects to two main tiles on the north side of Oakford which eventually empty into Martin-Youngman ditch. The Martin-Youngman ditch meanders through Izaak Walton Lake and eventually drains into Kokomo Creek.”	73 homes/ 9% illegal

Source: Howard County Health Department (1995, 1996, 1998).

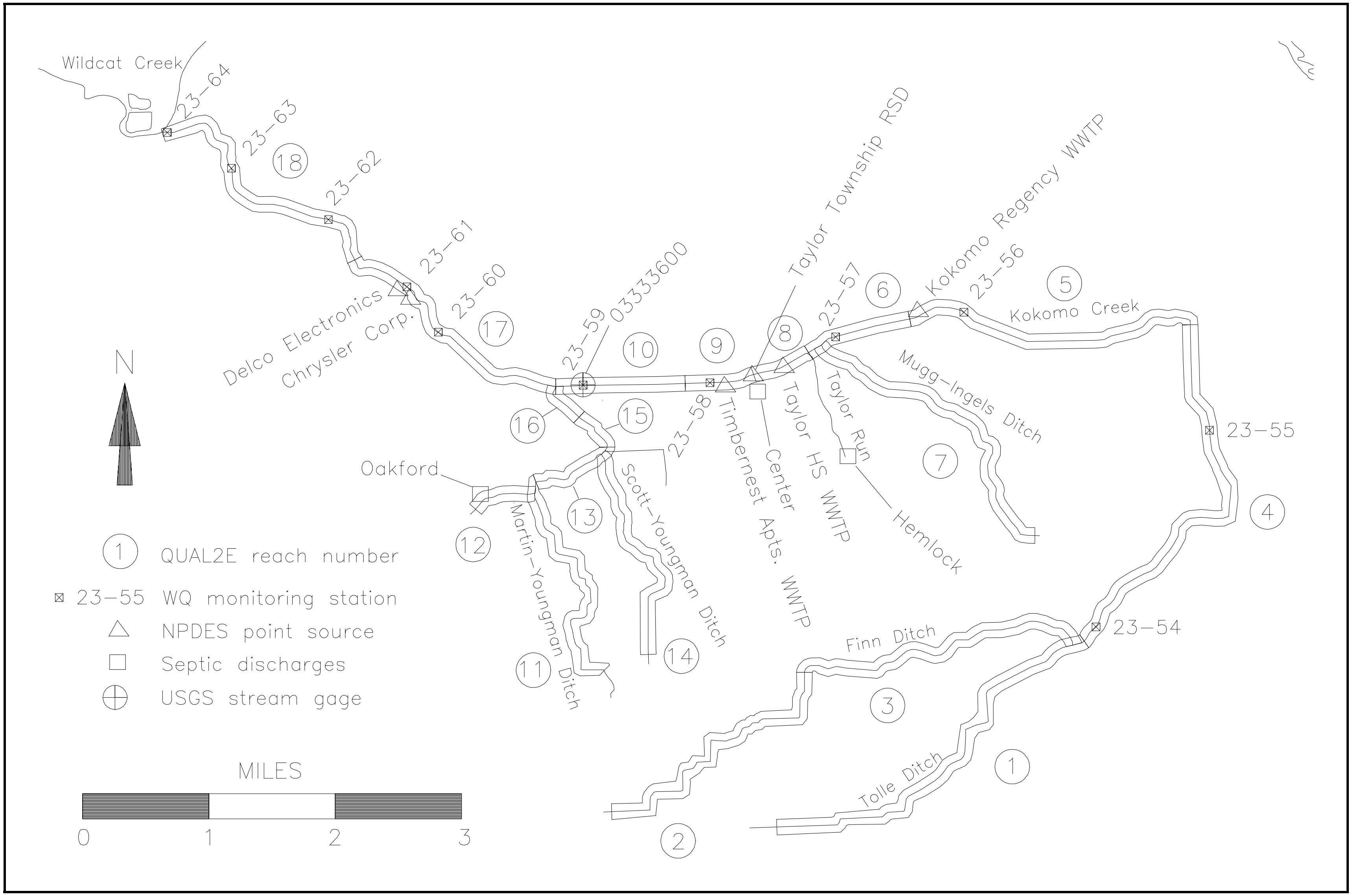

Figure 5. Locations of QUAL2E reaches, point sources, and monitoring stations for Kokomo Creek.

Effluent characteristics for the septic outfalls were obtained from literature values in the absence of sampling data (Thomann, 1972 as cited in USEPA, 1997b):

- CBODu: 220 mg/L
- Organic Nitrogen: 20 mg/L
- Total NH3-N: 28 mg/L
- NO3+NO2: 2 mg/L
- Total Phosphorus: 1 mg/L
- Average daily flow: 125 gallons/day/capita (average of 2.6 persons/household based on Howard County Census data (Bureau of the Census, 1990)).

4.1.3 Calibration of QUAL2E Model

In order to use a model as a predictive tool for water quality management, it is important that the model be calibrated to observed data. Calibration of the QUAL2E model requires an appropriate calibration condition determined from monitored instream water quality and point source discharge data. The IDEM instream water quality data set was available for Kokomo Creek from the sampling conducted in 1994 and 1998 (see section 2.2.1). In addition, DMR data for point source facilities along Kokomo Creek were available for 1993 to 1998.

The headwater boundary conditions and tributary conditions were estimated based on experience with past modeling studies since no data were available for these locations. The effluent discharge conditions used for model calibration were taken from the applicable monitoring data. All $CBOD_5$ concentrations were converted to ultimate CBOD ($CBOD_u$) for input to the model. A value of 2.84 was used for the $CBOD_u$:$CBOD_5$ ratio which is a recommended ratio for the type of treatment at these facilities (USEPA, 1997b). For the proposed new Taylor RSD facility, the $CBOD_u$:$CBOD_5$ ratio was assumed to be 2.3. For the headwater and tributaries, the $CBOD_u$:$CBOD_5$ ratio was assumed to be 1.0 (USEPA, 1997b).

The period selected for model calibration was September 3, 1998, which was characterized by low stream flow (2.9 cfs at the USGS stream gage on Kokomo Creek). The tributary stream flow and incremental flow along the stream network was determined by a ratio of contributing area of a given tributary to the contributing area at the USGS stream gage. The steady-state results of the QUAL2E model calibration run are presented in Appendix C (Figures C-01 to C-08). Reaeration was computed by the Melching and Flores (1999) method which was added to the QUAL2E model for this study and is a function of the stream velocity, slope, depth, width, flow rate, and temperature. The nitrate splits for the existing treatment facilities were 15% nitrite and 85% nitrate. The nitrate splits for the proposed new Taylor RSD facility were 10% nitrite and 90% nitrate. The model results for steady-state daily-average oxygen concentration match observed data reasonably well. The organic hydrolysis rates, ammonia oxidation rates, and nitrification rates were adjusted so that ammonia nitrogen, nitrate nitrogen, and total Kjeldahl nitrogen were in agreement with the limited instream data set. The biochemical oxygen demand (BOD) decay rate and BOD settling rate were adjusted to bring dissolved oxygen and BOD in agreement with the data observed during the calibration period. The temperature calculated by the model is a function of solar radiation, wind speed, air temperature, relative humidity, and canopy cover and agrees closely with water temperatures observed during the calibration period. The nitrogen and phosphorus nutrients simulated by the model also agree reasonably well with the data observations on September 3, 1998. Note that the model CBOD shown in Figure C-02 is ultimate CBOD whereas the observed data values are 5-day CBOD.

4.1.4 Validation of QUAL2E Model

The purpose of model validation is to determine if the kinetic rate parameters selected during model calibration are valid for an independent set of stream conditions and monitoring data. The period chosen for model validation was July 31, 1998. This period was characterized by higher stream flow than the calibration period (16 cfs at the USGS stream gage on Kokomo Creek). The kinetic rate constants for the validation run were identical to those used in the calibration run. The steady-state results of the validation run are shown in Figures C-09 to C-16. The results for all parameters agree well with the observed data. Note that the model CBOD shown in Figure C-10 is ultimate CBOD whereas the observed data are 5-day CBOD. An interesting feature of both the calibration and validation periods is the stream water temperature. On both sampling dates the temperature profile shows a decrease from river mile 7.5 to 4.3 followed by an increasing temperatures to the mouth of Kokomo Creek. The model calibration and validation results indicate that the chosen kinetic parameters are reasonable for low-flow summer conditions.

4.2 Upstream Nutrient Approach

The dissolved oxygen impairments at sites 23-54 and 23-56 have been determined to be due to the presence of excessive attached algal growths, as observed by IDEM staff and as indicated by the extreme dissolved oxygen swings. Furthermore, it is expected that elevated nutrient concentrations, habitat alterations, and reduced riparian cover are contributing to these excessive algal growths. Based on the sampling data, phosphorus has been determined to be the limiting nutrient (see section 2.1).

One approach to addressing the algal problem would be to apply a computer model that would attempt to simulate the relationship between instream nutrient concentrations, weather conditions, algal growth, and dissolved oxygen conditions. However, there are relatively few models available that can adequately simulate the effects of attached algae on water quality. Although the QUAL2E model can be used to simulate the effects of phytoplankton (free-floating) algae, no algae sampling data for the 1994 and 1998 sampling events are available for Kokomo Creek with which to calibrate the model. Furthermore, the problem in Kokomo Creek is assumed to be more of a result of attached algae than phytoplankton and QUAL2E does not as yet include an attached algae component. The lack of appropriate data also precludes the use of more complex models (such as the Hydrological Simulation Program - Fortran (HSPF)) that do include an attached algae component.

Because of these limitations, a more simplified approach was taken. The observed phosphorus concentrations at relatively unimpaired sites in the watershed was chosen as the TMDL endpoint. As discussed in section 2.1 a concentration of 0.10 mg/L total phosphorus was chosen using this method. This value matches the 0.10 mg/L target identified in USEPA's 1986 guidance document (USEPA, 1986) and also matches a TP criterion proposed by the Ohio Environmental Agency for watersheds in the Eastern Corn Belt Plains ecoregion (OEPA, 1999).

The existing total phosphorus concentration at Kokomo Creek is estimated to be 0.14 mg/L (based on the 1994 and 1998 sampling). Assuming a constant assimilation factor and using the total phosphorus loads estimated above indicates the need for reducing total phosphorus loadings from 8.87 t/year (see Table 8) to 6.34 t/year (or approximately a 29% reduction).

$$\frac{\text{Existing Condition}}{\text{TMDL Endpoint}} \approx \frac{0.14\ \text{mg / L TP}}{0.10\ \text{mg / L TP}} \approx \frac{8.87\text{t / yr TP}}{6.34\text{t / yr TP}}$$

As mentioned previously, it would be preferable to select a TMDL endpoint based on dissolved phosphorus concentrations rather than total phosphorus. This is because algae in a stream environment are more likely to respond to the readily bioavailable dissolved phosphorus than they are to the total phosphorus concentration. However, because only total phosphorus concentrations have been measured, it is not possible to accurately identify existing dissolved phosphorus concentrations at the impaired or the reference sites.

5.0 ALLOCATION

5.1 Description of TMDL Allocation

TMDLs are composed of the sum of individual waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is denoted by the equation

$$\text{TMDL} = \Sigma \text{ WLAs} + \Sigma \text{ LAs} + (\text{MOS})$$

5.1.2 Description of Allocation for Downstream Sources

Alternative #0 - Existing Permit Limits. The calibrated and validated QUAL2E model was used to evaluate water quality for the existing critical condition. The critical conditions were assumed to be:

- Point sources discharging at permit limits or maximum observed values for non-permitted parameters. Table 12 identifies the existing permit limits.
- Point sources discharging at their design flows
- Septic outfalls in Hemlock, Center, and Oakford discharging at their estimated flows and concentrations (see section 4.1.2)
- Maximum summer instream temperature of 24°C summer and 10°C winter based on IDEM recommendations.
- Instream pH of 7.8 based on IDEM recommendations.
- 7Q10 flow in stream (0.1 cfs)

The results of this analysis indicated that violations of the dissolved oxygen and total ammonia nitrogen criteria would occur during these critical conditions (see Figures C-19 and C-21). The minimum daily average dissolved oxygen concentration of 4.95 mg/L occurs at river mile 6.8, just downstream of Kokomo Regency WWTP.

Alternative #1 - Build New Taylor Regional Sewer District Plant (Design Capacity 0.25 mgd)
Under this alternative a new Taylor Regional Sewer District (RSD) would be formed and a new treatment plant would be built. This plant would treat waste from the existing septic outfalls, as well as waste from the Kokomo Regency Mobile Home Park and Taylor High School. The design capacity of the new plant under Alternative #1 is 0.25 mgd and the outfall would be located at mile point 5.73. The QUAL2E model was used to identify permit limits for this scenario and Table 13 identifies the limits that will eliminate any impairment at the critical condition, and therefore will also be protective of water quality standards at any other conditions.

Alternative #2 - Build New Taylor Regional Sewer District Plant (Design Capacity 0.25 mgd) and Remove Timbernext STP

For this alternative, the new Taylor RSD plant would also handle waste from Timbernest Apartments. The design capacity would continue to be 0.25 mgd. Table 14 shows the allocation for this alternative.

Alternative #3 - Build New Taylor Regional Sewer District Plant (Design Capacity 0.50 mgd) and Remove Timbernext STP

For this alternative, the new Taylor RSD plant would handle waste from Timbernest Apartments and the design capacity would be increased to 0.50 mgd. Table 15 shows the allocation for this alternative.

Since IDEM only allows 50% of the streamflow to be used for the ammonia toxicity allocation, the permit limits for ammonia nitrogen were computed separately outside the QUAL2E model. After allocating ammonia nitrogen to meet the ammonia toxicity criteria, the allowable total ammonia nitrogen concentrations were input to the QUAL2E model, and CBOD, ammonia nitrogen, and nitrate nitrogen were allocated to protect the dissolved oxygen water quality standard. The ammonia toxicity calculations were based on the following dilution equation:

$$C_d = \frac{(Q_{u/2} \times C_u + Q_e \times C_e)}{Q_{u/2} + Q_e}$$

where,

Q_u	= upstream flow rate (0.1 cfs)
$Q_{u/2}$	= 50% of upstream flow rate (0.05 cfs)
C_u	= upstream ammonia nitrogen concentration (0.2 mg/L)
Q_e	= effluent flow rate (0.25 or 0.50 mgd)
C_e	= effluent ammonia nitrogen concentration (solve for this)
C_d	= allowable downstream ammonia nitrogen concentration (from criteria)

The water quality criteria for total ammonia nitrogen was 1.350 mg N/L for summer critical conditions (temperature 24°C and pH 7.8) and 1.887 mg/L for winter critical conditions (10°C and pH 7.8). The effluent concentration (C_e) was adjusted so that the downstream concentration (C_d) did not exceed the water quality criteria. The ammonia allocation for the upstream-most point source (Taylor Township RSD) was computed first and the ammonia concentration was entered into QUAL2E in order to determine the upstream concentration (C_u) for the next downstream source (Timbernest Apartments). The ammonia toxicity computations are summarized in Table 11 below.

Table 11. Ammonia nitrogen toxicity allocations for Kokomo Creek WWTPs.

Description	Taylor Township RSD (0.25 mgd)	Timbernest Apartments WWTP	Taylor Township RSD (0.50 mgd)
Qu = upstream flow (cfs)	0.10	0.4868	0.10
Qu/2 = 50% of upstream flow (cfs)	0.05	0.2434	0.05
Cu = summer upstream NH3-N conc. (mg N/L) *Cu* = winter upstream NH3-N conc. (mg N/L)	0.200 0.200	1.229 1.710	0.200 0.200
Qe = effluent flow (cfs)	0.3868	0.0232	0.7736
Ce = summer effluent NH3-N conc (mg N/L) *Ce* = winter effluent NH3-N conc. (mg N/L)	1.50 2.10	2.61 3.73	1.42 1.99
Qd = downstream flow (cfs)	0.4868	0.2666	0.8736
Cd = summer downstream NH3-N conc. (mg N/L) *Cd* = winter downstream NH3-N conc. (mg N/L)	1.347 1.883	1.349 1.886	1.346 1.881

Table 12. Conditions used for Kokomo Creek low flow analysis.

Facility Name	Flow (mgd)	CBOD5 (mg/L)	NH3-N (mg N/L)	DO (mg/L)	NO2+NO3 (mg N/L)
Kokomo Regency	0.091 [0.1408 cfs]	15 (a)	1.2 (a)	6.0 (a)	3.3
Hemlock Septic	0.007 [0.0108 cfs]	220 (b)	28.0 (b)	2.0 (b)	2.0 (b)
Taylor High School	0.0284 [0.0439 cfs]	15	3.4 (c)	6.0	30.0
Center Septics	0.007 [0.0108 cfs]	220 (b)	28.0 (b)	2.0 (b)	2.0 (b)
Timbernest Apartments	0.015 [0.0232 cfs]	25	3.9	2.9 (d)	9.1
Oakford Septics	0.012 [0.0186 cfs]	220 (b)	28.0 (b)	2.0 (b)	2.0 (b)
Delco (e)	-	-	-	-	-
Chrysler (f)	-	-	-	-	-

Notes:

(a) interim permit limits based on permit re-issued on 04/23/99

(b) values for septic discharges are estimated and CBOD values are ultimate instead of 5-day

(c) maximum observed ammonia nitrogen (12/93)

(d) minimum observed dissolved oxygen

(e) Delco permit will be re-issued as a general stormwater permit and is not included in the low-flow TMDL analysis

(f) Chrysler permit is a general stormwater permit and is not included in the low-flow TMDL analysis

Table 13. Allocations for Alternative #1.

Facility Name	Flow (mgd)	CBOD5 (mg/L)	NH3-N (mg N/L)	DO (mg/L)
Taylor Township RSD	0.25 [0.3868 cfs]	15.0 summer 25.0 winter	1.50 summer 2.01 winter	6.0 summer 5.0 winter
Timbernest Apartments	0.015 [0.0232 cfs]	25.0 summer 25.0 winter	2.61 summer 3.73 winter	N/A (2.9)
Kokomo Regency	Connected to Taylor Township RSD			
Hemlock Septic	Connected to Taylor Township RSD			
Taylor High School	Connected to Taylor Township RSD			
Center Septics	Connected to Taylor Township RSD			
Oakford Septics	Connected to Taylor Township RSD			

Table 14. Allocations for Alternative #2.

Facility Name	Flow (mgd)	CBOD5 (mg/L)	NH3-N (mg N/L)	DO (mg/L)
Taylor Township RSD	0.25 [0.3868 cfs]	15.0 summer 25.0 winter	1.50 summer 2.10 winter	6.0 summer 5.0 winter
Timbernest Apartments	Connected to Taylor Township RSD.			
Kokomo Regency	Connected to Taylor Township RSD			
Hemlock Septic	Connected to Taylor Township RSD			
Taylor High School	Connected to Taylor Township RSD			
Center Septics	Connected to Taylor Township RSD			
Oakford Septics	Connected to Taylor Township RSD			

Table 15. Allocations for Alternative #3.

Facility Name	Flow (mgd)	CBOD5 (mg/L)	NH3-N (mg N/L)	DO (mg/L)
Taylor Township RSD	0.50 [0.7736 cfs]	10.0 summer 25.0 winter	1.42 summer 1.99 winter	6.0 summer 5.0 winter
Timbernest Apartments	Connected to Taylor Township RSD			
Kokomo Regency	Connected to Taylor Township RSD			
Hemlock Septic	Connected to Taylor Township RSD			
Taylor High School	Connected to Taylor Township RSD			
Center Septics	Connected to Taylor Township RSD			
Oakford Septics	Connected to Taylor Township RSD			

The Kokomo Creek dissolved oxygen and nutrient TMDL for the point and nonpoint sources in their present locations can also be expressed in terms of daily mass loading as follows:

$$TMDL = \sum WLA + \sum LA + MOS$$

The load allocation (nonpoint sources and natural background) shown in Table 16 are calculated based on the tributary headwater inflow and the lateral inflow components of the QUAL2E model. They represent the estimated loads entering Kokomo Creek during low-flow conditions.

Table 16. Daily mass load TMDL allocations for CBOD5 and total ammonia nitrogen.

Alternative	Season	CBOD5 (kg/day)			Total Ammonia Nitrogen (kg/day)		
		WLA	LA	MOS	WLA	LA	MOS
#1	summer	15.617	0.568	implicit	1.568	0.187	implicit
	winter	25.081	0.568	implicit	2.095	0.187	implicit
#2	summer	14.197	0.568	implicit	1.420	0.187	implicit
	winter	23.611	0.568	implicit	1.883	0.187	implicit
#3	summer	18.929	0.568	implicit	2.688	0.187	implicit
	winter	47.323	0.568	implicit	3.767	0.187	implicit

5.1.3 Description of Allocation for Upstream Sources

Section 4.2 indicates that total phosphorus loads from subwatersheds 5, 6, and 7 need to be reduced approximately 29%, from 8.87 metric tons/year to 6.34 metric tons/year. The following allocation will achieve this reduction.

Table 17. TMDL allocation for upstream dissolved oxygen impairment.

Source	Existing Tot. P (t)	Allocation Tot. P (t)	Reduction
Row Crop (No conservation tillage)	6.83	4.54	-34%
Row Crop (Conservation tillage)	0.87	0.87	0%
Groundwater	0.86	0.86	0%
Point Source	0.24	0	100%
Pasture/Hay	0.05	0.05	0%
Wetlands	0.02	0.02	0%
Low Intensity Residential	0	0	0%
High Intensity Residential	0	0	0%
Commercial/Urban	0	0	0%
Deciduous Forest	0	0	0%
Urban Grasslands	0	0	0%
Total	8.87	6.34	-29%

The TMDL can also be expressed as:

TMDL = ∑WLA + ∑LA + MOS

TMDL = 0.00 t/year TP + 5.48 t/year TP Nonpoint Sources + 0.86 t/yr TP Groundwater + Implicit MOS (See Section 5.2)

This allocation indicates the need for reducing TP loadings from row crop agriculture by 34% after accounting for the fact that TP loadings from the Kokomo Regency Mobile Home Park will be zero after it is connected to the Taylor Township RSD.

5.2 Incorporating a Margin of Safety

Section 303(d) and the regulations at 40 CFR 130.7 require that “TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality.” The margin of safety can either be incorporated into conservative assumptions used to develop the TMDL or added as a separate component of the TMDL (USEPA, 1991).

The margin of safety for this TMDL has been implicitly accounted for in two ways:

1) The assumptions for the low-flow critical condition for the QUAL2E model are very conservative (e.g., 7Q10 low flow, 24° C temperature, pH 7.8, facilities discharging at their design capacities and permit limits).
2) The total phosphorus endpoint of 0.10 mg/L TP was selecting using fairly rigorous criteria for identifying reference sites. This endpoint was chosen by identifying the sampling sites in the IDEM watershed that had very good dissolved oxygen conditions (an average dissolved oxygen concentration of at least 7.0 mg/L and dissolved oxygen swings of less than 2.0 mg/L per day) and calculating their average TP concentrations. If a less rigorous TMDL endpoint had been selected, the estimated necessary loading reductions would not have been as great. For example, if an endpoint of 0.12 mg/L TP had been chosen rather than 0.10 mg/L TP, the loading capacity would have been 1.440 metrics tons/year instead of 1.200 metric tons/year (an explicit MOS of 17%).
3) During the winter season, the margin of safety is incorporated by capping the allowable effluent CBOD5 concentrations at 25 mg/L for the Taylor Township RSD facility.

6.0 IMPLEMENTATION

The load reductions from the point sources in the watershed will be implemented via the NPDES program. The elimination of the septic outfalls and the discharge from Kokomo Regency and Taylor High School will be addressed by the formation of the Taylor Township RSD. The Taylor Township RSD has already requested preliminary effluent limits and is currently working on design of the plant. The request stated that the proposed plant will be an extended aeration/activated sludge plant with ultraviolet disinfection.

The Indiana Department of Natural Resources has initiated a Lake and River Enhancement project for the upstream portion of Kokomo Creek. The objective of the project is to work with land users (primarily agricultural) to reduce soil erosion and associated soil and nutrient movement into surface waters. This is to be accomplished by providing technical and financial assistance to land users voluntarily desiring to participate in the program. Cost-share funds will be offered to encourage the installation of vegetative filter strips, grassed waterways, grade stabilization structures, and other measures as well as to promote the adoption of practices such as livestock waste utilization, reduced tillage, and integrated pest (and nutrient) management. This project is in its early stage of development, and since participation is entirely voluntary, it is impossible to predict the ultimate level of land user involvement.

Filter strips have a reported 75% effectiveness for controlling total phosphorus (Pennsylvania State University, 1992 as cited in USEPA, 1993) and the other conservation measures included in the IDNR project are also very effective at reducing soil erosion and total phosphorus. Assuming the project goes forward as planned, the combination of the filter strips and other measures, as well as any increase in the use of conservation tillage in the watershed, should result in the necessary 34% reduction in total phosphorus loadings from row crop agriculture (see Table 17). In addition, the proposed conservation measures could potentially improve the health of the riparian corridor by re-vegetating the streambanks and improving instream and floodplain habitat.

6.1 Follow-up Monitoring

The surface water sampling for this project will take place in the year 2001 and will occur in phases as each part of the TMDL Implementation Plan is completed. The stream will be sampled three times annually during both high flow and low flow conditions for a period of three years to insure compliance with water quality standards. Samples will be collected three times between the months of March and October to reflect the effects of varying stream flow and weather conditions. Samples from the Taylor Township Regional Sewer District plant final effluent, once operational, will be collected as 2 part composites. All stream surface water samples will be collected as grab samples, and will be analyzed for ammonia-nitrogen and total phosphorus. At each location, when a water sample is taken, field tests for pH, temperature, turbidity, specific conductance, chlorophyll a, and dissolved oxygen will be conducted using a YSI™ multi-parameter water chemistry analyses unit. The dissolved oxygen measurements will be collected late afternoon, (3:30 pm to 6:00 pm) (peak dissolved oxygen period), and before dawn the following morning (2:30 am to 4:30 am) (low dissolved oxygen period). The stream samples will be collected from the centroid of flow, just below the surface of the water. The nearby USGS stream gage on Wildcat Creek at Kokomo (03333700) will be monitored to estimate area stream flow levels. All water samples will be preserved as described in the Quality Assurance Program Plan. Water samples for the nutrients analysis will be preserved appropriately with sulfuric acid, on ice at 4°C +/- 2°, and delivered to the Indiana State Department of Health Laboratory for analysis within standard holding times.

6.2 Reasonable Assurance

The Taylor Township Regional Sewer District was formed on September 5, 2000, and they have applied for State Revolving Loan funds for construction of the plant and sewer lines. The sewer project will take in not only the Taylor High School wastewater treatment plant, but the Regency Mobile Home Park and the Timbernest Apartments, eliminating all of the small package wastewater treatment plants that have been contributing to the impairments in Kokomo Creek. Construction of the plant and sewer lines should begin sometime in 2001. IDEM's existing authority under the NPDES program will be used to implement any additional point source modifications necessary, should water quality improvements not be realized.

The Lake and River Enhancement Grant project is currently underway, with two of the three major landowners participating. Funds available for 1999 were $30,000; for 2000, $35,000; and an additional $18,350 has been requested for 2001 activities. Additionally, the Howard County Soil and Water Conservation District (SWCD) has the expertise of four employees to assist landowners in the watershed with LARE projects. In addition, technicians from the Howard County Soil and Water Conservation District, the Natural Resource Conservation Service (NRCS) and the Indiana Department of Natural Resources (IDNR) will provide the SWCD Board with a yearly progress report on each conservation practice installed in the program. Practices will be inspected to insure that they are meeting NRCS specifications and are working properly. Should the current and planned activities not be effective in reducing phosphorus loadings and improving dissolved oxygen levels, additional education and outreach activities will be undertaken.

6.3 Public Participation

The Indiana Department of Environmental Management has held three public meetings for the Kokomo Creek Watershed interested parties. All stakeholders were sent advanced notice of the meetings, and the notices appeared on IDEM's Calendar of Events and on the agency website. The first meeting was held in Kokomo at the government center on December 21, 1999 and had an attendance of 25. Staff from IDEM and the Howard County Health Department presented information about the water quality problems in Kokomo Creek, and described the TMDL process. The second meeting was held February 16, 2000 at the Taylor Township Volunteer Fire Department's Community Room located in the watershed. Twenty-five people were in attendance, and the draft TMDL results were presented. The third meeting was held November 8, 2000 at the Taylor Township Volunteer Fire Department's Community Room, and copies of the TMDL were distributed for the official public comment period, which runs from November 10 through December 11, 2000. The public meeting and comment period announcement were placed on IDEM's website, advertised in the Kokomo newspaper, and mailed to all of the stakeholders in the area. The Kokomo Creek TMDL was placed on IDEM's website, and copies were placed at the Kokomo- Howard County Public Library, main branch, and the south branch, located in Taylor Township, as well as made available at the public meeting.

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Appendix A – Results of IDEM Sampling

Date	Sampling Site Number	NH3-N (mg/L)	NO3NO2-N (mg/L)	TKN (mg/L)	TP (mg/L)	CBOD5 (mg/L)	DO Max (mg/L)	DO Mean (mg/L)	DO Min (mg/L)	pHAvg	pHMax	pHMin	Temp Mean (C)	Flow (cfs)
12/03/1993	Regency MHP	5.4	3.3	5.9	1.0		7.5	7.1	6.6	7.7	7.8	7.6	4	0.100
12/03/1993	Regency MHP	12	0.4	33	3.4									
12/03/1993	Taylor HS	3.4	16	5.7	9.6		5.5	4.8	4.2	7.5	7.5	7.4	11	0.030
12/03/1993	Timbernest Apts	0.2	0.2	1.0	0.4								4	0.020
06/15/1994	23-64	0.2	1.5	0.6	0.13	1.5	7.4	6.5	5.7	8.0	8.4	7.6	24.0	8.460
06/17/1994	Timbernest Apts	0.4	0.1	1.4	0.4	4.0		4.8		7.5	7.5		27.0	0.020
06/17/1994	Regency MHP	6.9	1.5	9.1	2.6	4.2		4.9		7.5	7.5		27.0	0.050
06/17/1994	Delco Electronics	0.1	1.9	0.5	0.28	1.0		8.6		7.7	7.7		26.0	3.270
06/17/1994	Chrysler Corp	0.2	1.4	0.6	0.18	1.0		7.1		7.7	7.7		29.0	0.380
06/17/1994	23-64	0.2	2.1	0.6	0.14	1.0	7.5	6.4	4.3	8.0	8.1	7.8	26.0	8.220
06/17/1994	23-63	0.2	2.2	0.7	0.17	1.3	8.5	7.3	5.0	8.0	8.1	7.8	26.0	
06/17/1994	23-62	0.1	2	0.6	0.16	1.1	7.9	6.6	4.5	8.0	8.1	7.8	25.0	11.160
06/17/1994	23-61	0.1	2.1	0.6	0.17	1.0	7.8	6.7	4.7	7.9	8.1	7.7	25.0	10.990
06/17/1994	23-60	0.1	2.6	0.5	0.13	1.0	7.3	6.8	6.2	7.8	7.9	7.6	25.0	5.450
06/17/1994	**23-59**	0.1	2.3	0.6	0.14	1.0	6.3	5.0	**3.4**	7.7	7.7	7.6	24.0	4.300
06/17/1994	23-58	0.2	2.4	0.7	0.18	1.0	6.5	5.9	5.4	7.8	7.8	7.7	25.0	3.070
06/17/1994	23-57	0.3	2.5	1.4	0.36	1.4	6.6	5.8	5.1	7.8	7.9	7.6	26.0	
06/17/1994	**23-56**	0.2	2.4	0.7	0.12	1.0	7.9	5.6	**3.6**	7.8	8.0	7.6	26.0	2.920
06/17/1994	23-55	0.2	2.3	0.7	0.14	1.5	11.6	6.8	4.3	8.0	8.3	7.6	25.0	
06/17/1994	**23-54**	0.2	1.7	0.9	0.18	1.0	9.4	5.9	**3.7**	7.8	8.1	7.5	26.0	1.030
07/31/1998	Regency MHP	3.7	0.1	7.7	1.03	14	7.33	5.26	3.88	7.7	7.84	7.51	22.19	0.039
07/31/1998	Chrysler Corp	0.4	0.5	0.9	0.24	1.1		5.98		7.8	7.77		22.67	0.34
07/31/1998	23-64	0.1	2.7	0.5	0.11	1.0	8.29	7.98	7.73	8.0	8.08	7.98	20.91	20.74
07/31/1998	23-63	0.1	2.8	0.4	0.09	1.0	8.38	8.27	8.17	7.1	8.16	6.07	21.24	21.48
07/31/1998	23-62	0.1	2.8	0.4	0.09	1.0	8.56	8.15	7.83	8.0	8.09	7.98	20.96	18.85
07/31/1998	23-61	0.1	3.1	0.5	0.01	1.0	8.13	7.84	7.58	8.0	7.99	7.94	20.85	17.26
07/31/1998	23-60	0.1	3.2	0.5	0.02	1.0	7.99	7.72	7.46	7.9	7.97	7.92	20.81	17.21
07/31/1998	23-59	0.1	3.4	0.5	0.09	1.0	7.37	7.24	7.03	7.8	7.84	7.77	20.63	16.0
07/31/1998	23-58	0.1	3.6	0.6	0.09	1.0	7.56	7.34	7.01	7.8	7.83	7.77	20.6	12.38
07/31/1998	23-57	0.1	3.8	0.6	0.09	1.1	8.03	7.33	6.73	7.8	7.85	7.72	20.78	10.32

Date	Sampling Site Number	NH3-N (mg/L)	NO3NO2-N (mg/L)	TKN (mg/L)	TP (mg/L)	CBOD5 (mg/L)	DO Max (mg/L)	DO Mean (mg/L)	DO Min (mg/L)	pHAvg	pHMax	pHMin	Temp Mean (C)	Flow (cfs)
07/31/1998	23-56	0.1	3.7	0.5	0.08	1.0	10.41	8.38	6.99	7.8	8.03	7.65	20.8	10.5
07/31/1998	23-55	0.1	3.9	0.6	0.11	1.0	8.32	7.14	6.5	7.7	7.77	7.6	20.28	6.66
07/31/1998	23-54	0.1	4.3	0.5	0.09	1.0	8.09	7.46	7.07	7.8	7.9	7.75	19.61	3.65
09/03/1998	Timbernest Apts.	0.82	9.1	2.5	3.6	2.0	3	2.95	2.9	7.2	7.2	7.15	20.25	0.008
09/03/1998	Taylor High School	0.12	30	0.56	4.1	2.0	7.9	7.85	7.8	8.1	8.06	8.05	23.6	0.03
09/03/1998	Regency MHP	10	0.052	14	1.7	55.0	2.3	2.1	1.9	7.4	7.35	7.35	21	0.07
09/03/1998	Delco Electronics	0.1	0.63	0.1	0.42	2.0	8	8	8	7.9	7.86	7.86	23.4	5.681
09/03/1998	Chrysler Corp.	0.13	0.08	0.51	0.11	2.0	6.13	6.13	6.13	7.7	8.26	7.2	22.24	0.104
09/03/1998	23-64	0.1	0.58	0.38	0.2	2.0	9	8.3	7	8.1	8.16	8.07	20.45	4.18
09/03/1998	23-63	0.1	0.51	0.36	0.17	2.0	8.5	8.35	8.18	8.2	8.2	8.16	20.74	4.82
09/03/1998	23-62	0.1	0.65	0.24	0.19	2.0	10.2	8.59	6.9	8.1	8.2	8.03	19.86	4.18
09/03/1998	23-61	0.12	0.82	0.36	0.26	2.0	9.5	8.1	6.75	8.0	8.1	7.96	19.85	4.74
09/03/1998	23-60	0.1	0.67	0.81	0.16	2.0	9	8.11	7.21	8.1	8.1	8.01	18.59	2.67
09/03/1998	23-59	0.1	0.74	0.1	0.19	2.0	6.7	6.28	5.95	7.8	7.85	7.83	18.18	2.9
09/03/1998	23-58	0.14	0.88	0.69	0.22	2.0	6.1	5.86	5.61	7.7	7.88	7.54	18.75	1.8
09/03/1998	23-57	0.34	0.51	0.86	0.19	2.0	6.1	5.32	4.42	7.8	7.82	7.74	20.06	1.13
09/03/1998	23-56	0.18	0.14	0.87	0.15	2.0	13.5	8.02	**3.77**	8.0	8.3	7.65	21.84	0.81
09/03/1998	23-55	0.18	0.25	1	0.17	2.0	11.3	8.4	6.63	7.9	7.99	7.77	20.46	0.71
09/03/1998	23-54	0.18	0.34	0.7	0.2	2.0	7.4	7.1	6.8	7.9	7.97	7.86	19.08	0.12

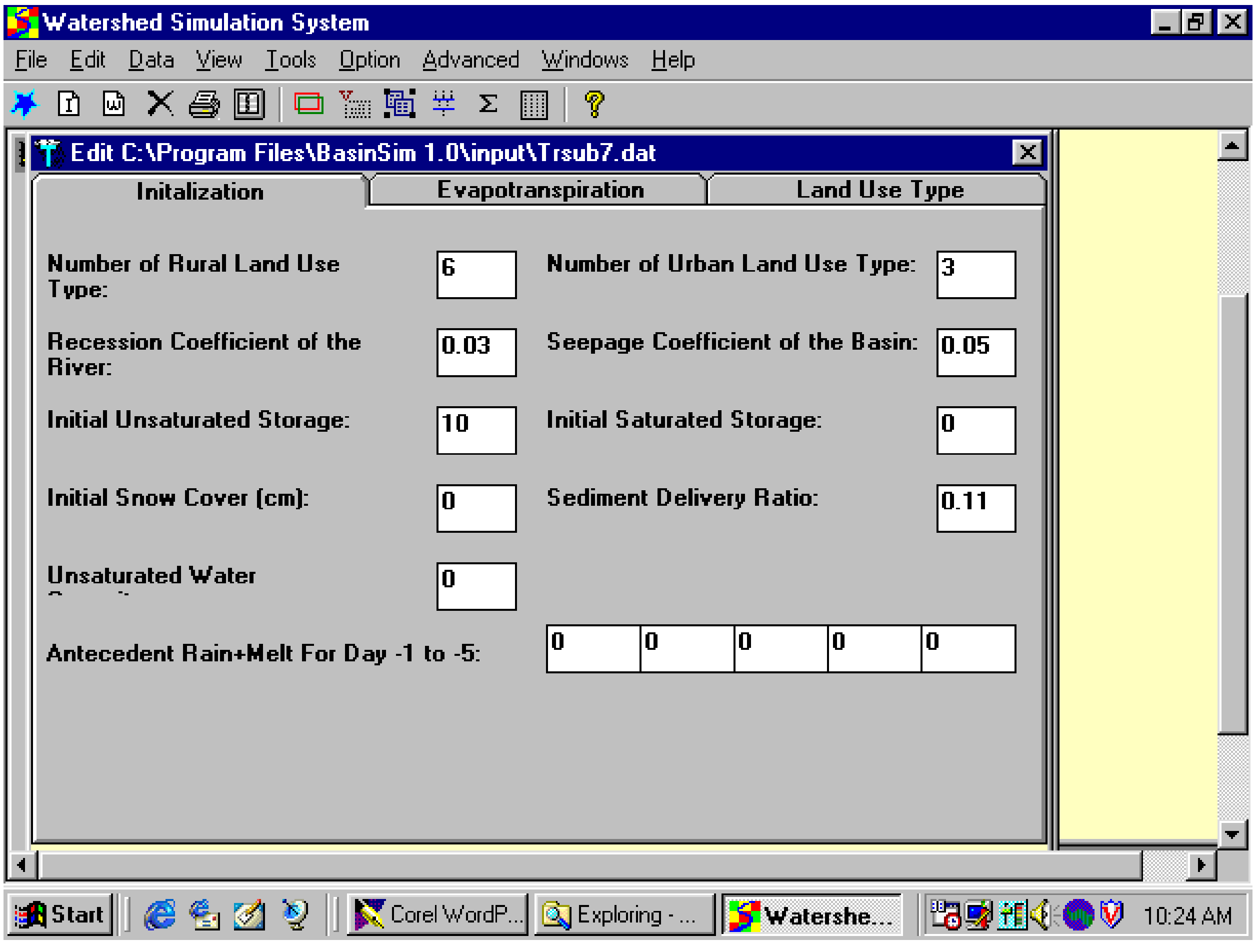
Key to acronyms:

DO: Dissolved Oxygen
Temp: Temperature
NH3-N: Ammonia-Nitrogen
NO3-NO2N: Nitrate-Nitrite Nitrogen
TKN: Total Kjeldahl Nitrogen
TN: Total Nitrogen
TP: Total Phosphorus
COD: Chemical Oxygen Demand
CBOD5: Carbonaceous Biochemical Oxygen Demand (over a 5 day period)

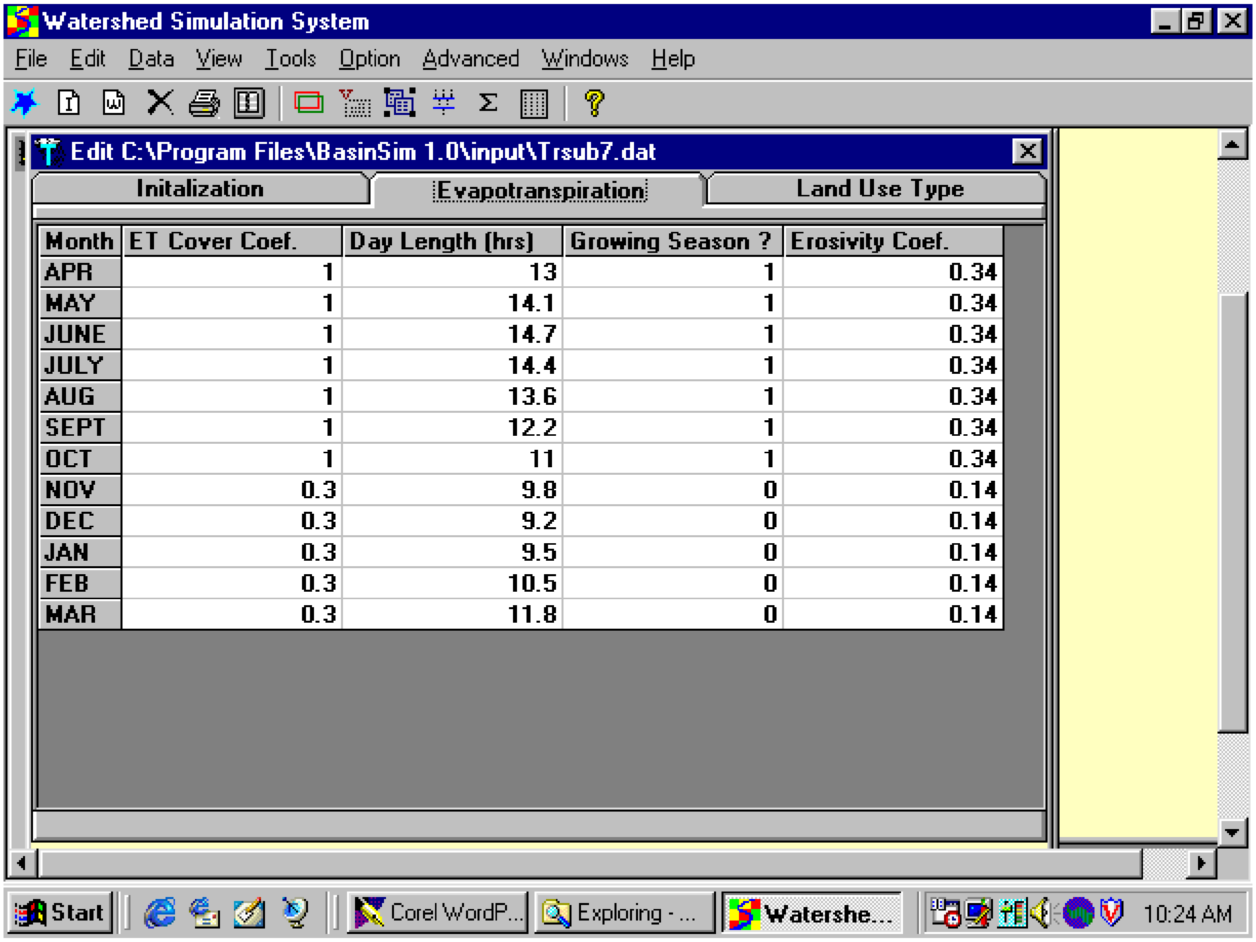
Appendix B: GWLF Modeling

Time Period:	4/01/94 to 3/31/99
Meteorologic Data:	Daily temperature and precipitation data obtained from the Kokomo Post Office (Station ID: 124662) via the Midwestern Climate Center in Champaign, Illinois (http://mcc.sws.uiuc.edu/).
Hydrologic Data:	Daily flow data obtained for USGS gage Kokomo Creek Near Kokomo, Indiana (Station number: 03333600). Downloaded from www.usgs.gov.

Initialization Parameters:

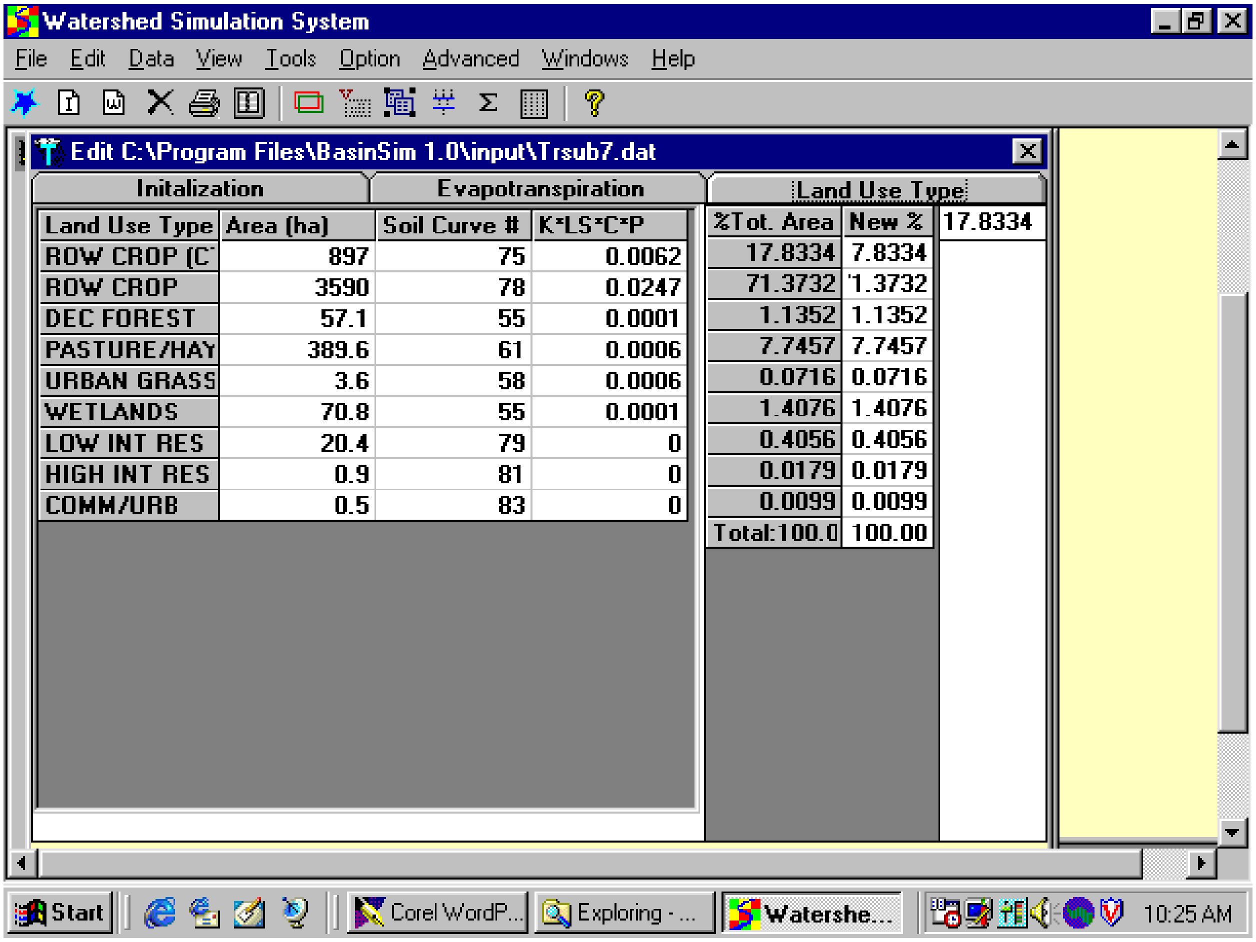


Evapotranspiration Parameters:

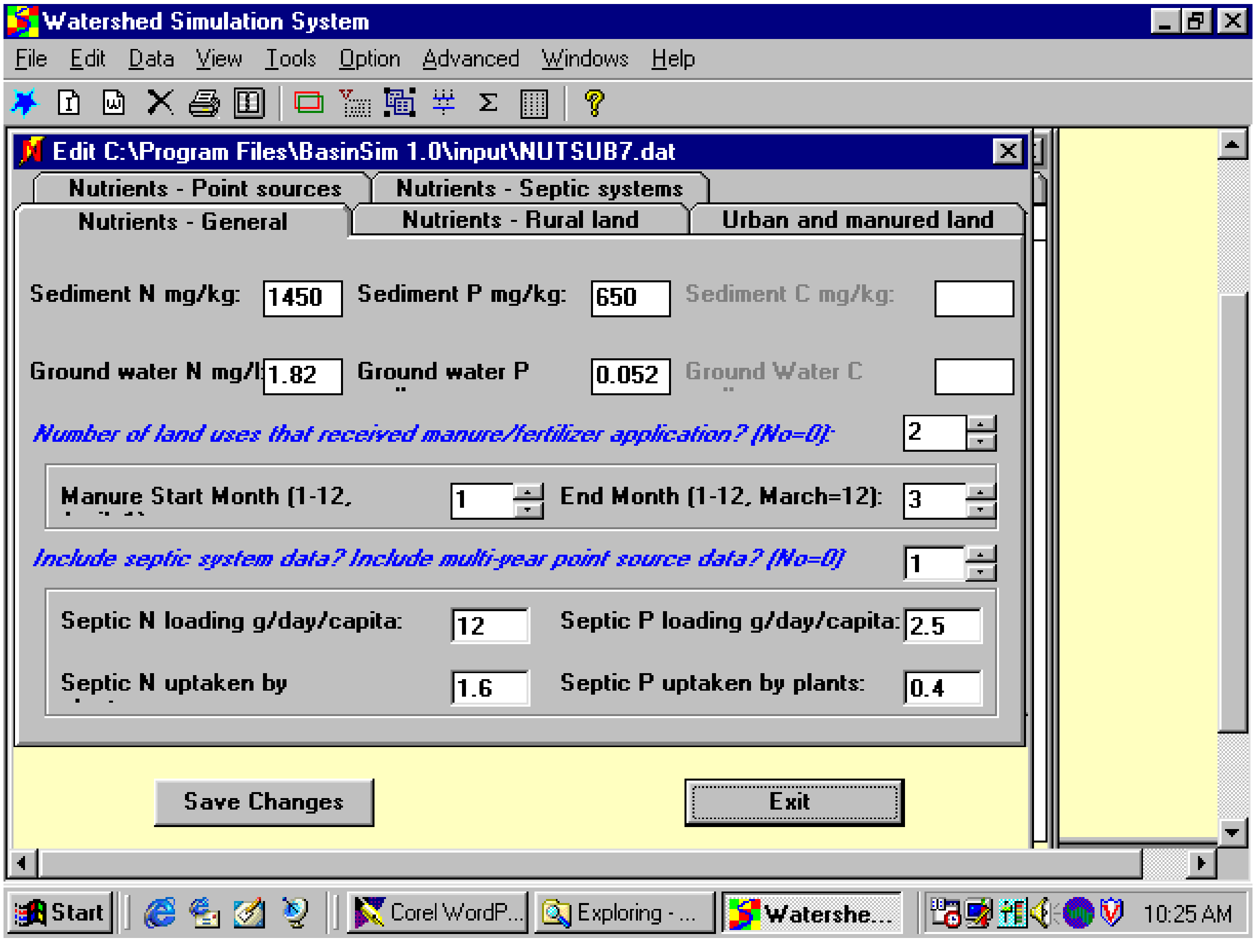


Month	ET Cover Coef.	Day Length (hrs)	Growing Season ?	Erosivity Coef.
APR	1	13	1	0.34
MAY	1	14.1	1	0.34
JUNE	1	14.7	1	0.34
JULY	1	14.4	1	0.34
AUG	1	13.6	1	0.34
SEPT	1	12.2	1	0.34
OCT	1	11	1	0.34
NOV	0.3	9.8	0	0.14
DEC	0.3	9.2	0	0.14
JAN	0.3	9.5	0	0.14
FEB	0.3	10.5	0	0.14
MAR	0.3	11.8	0	0.14

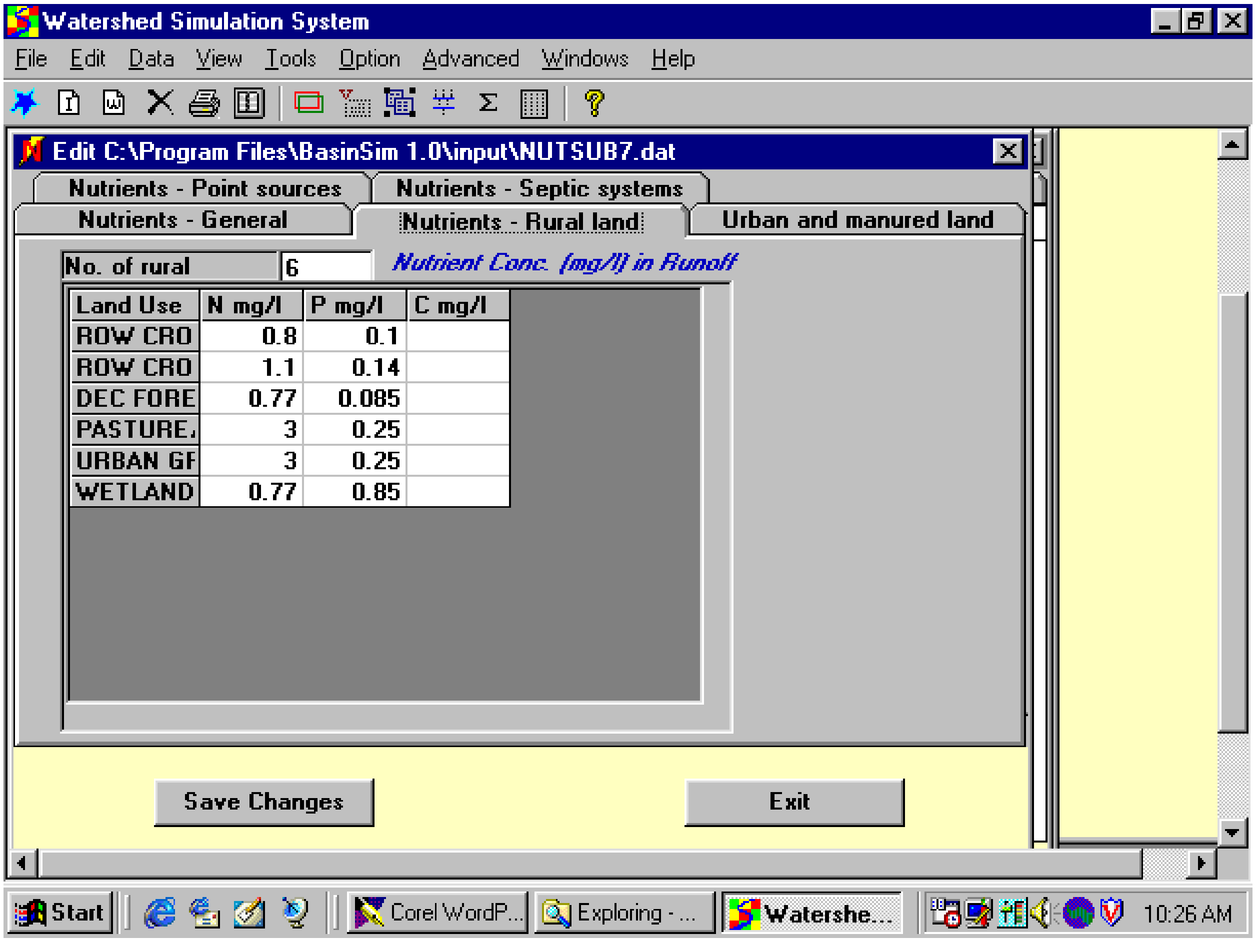
Land Use Type Parameters:



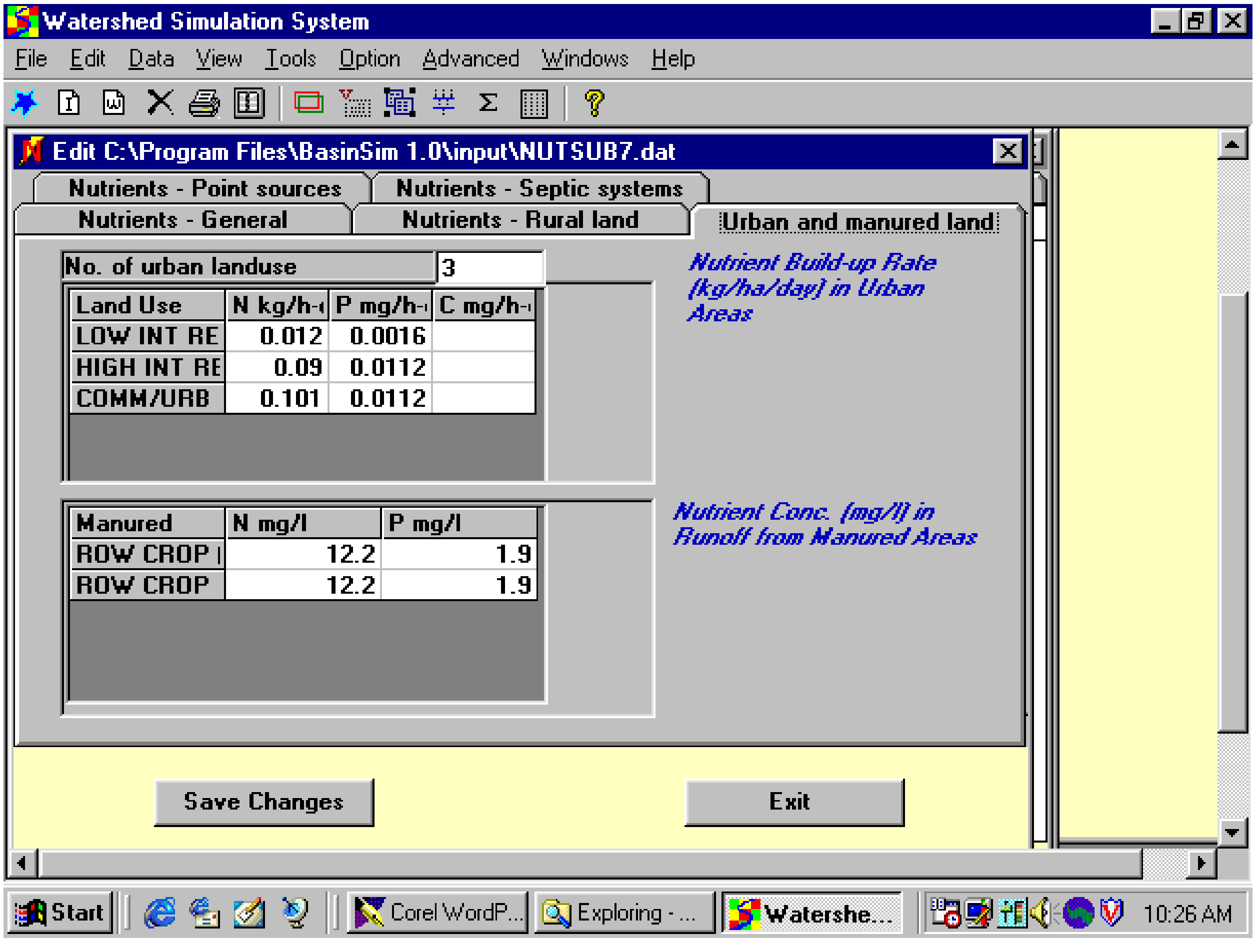
General Nutrient Parameters:



Rural Land Use Nutrient Parameters:



Urban and Manured Land:



Nutrients - Point Sources